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Cognition in Action *C-i-A*
Re-thinking Gesture in Neuro-atypical Young People
A Conceptual Framework for Embodied, Embedded, Extended and
Enacted Intentionality

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To

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Abstract

The three aims of my interdisciplinary thesis are:

- *To develop a conceptual framework for re-thinking the gestures of neuro-atypical young people, that is non-traditional and non-representational*
- *To develop qualitative analytical tools for the annotation and interpretation of gesture that can be applied inclusively to both neuro-atypical and neuro-typical young people*
- *To consider the conceptual framework in terms of its theoretical implications and practical applications*

Learning to communicate and work with neuro-atypical young people provides the rationale and continued impetus for my work. My approach is influenced by the limited social, physical and communicative experiences of young people with severe speech and motor impairment, due to cerebral palsy (SSMI-CP). CP is described as: *a range of non-progressive syndromes of posture and motor impairment. The aetiology is thought to result from damage to the developing central nervous system during gestation or in the neonate.* Brain lesions involve the basal ganglia and the cerebellum; both these sites are known to support motor control and integration.

However, gaps in theoretical research and empirical data in the study of corporeal expression in young people with SSMI-CP necessitated the development of both an alternative theoretical framework and new tools. Biological *Dynamic Systems Theory* is proposed as the best candidate structure for the reconsideration of gesture. It encompasses the global, synthetic and embodied nature of gesture. Gesture is redefined and considered part of an emergent dynamic, complex, non-linear and self-organizing system.

My construct of *Cognition-in-Action (C-i-A)* is derived from the notion of *knowing-as-doing* influenced by socio-biological paradigms; it places the *Action-Ready-Body* centre stage. It is informed by a theoretical synthesis of knowledge from the domains of *Philosophy, Science* and *Technology*, including practices in the clinical, technology design and performance arts arenas. The C-i-A is a descriptive, non-computational feature-based framework. Its development centred around two key questions that served as operational starting points: *What can gestures reveal about children's cognition-in-action?* and *Is there the potential to influence gestural capacity in children?* These are supported by my research objectives.

Three case studies are presented that focus on the annotation and interpretative analyses of corporeal exemplars from two adolescent males aged 16.9 and 17.9 years, and one female girl aged 10.7 years. These exemplars were contributed to the Child Gesture Corpus by these young people with SSMI-CP. The Gesture-Action-Entity (GAE) is proposed as a unit of interest for the analysis of *procedural, semantic* and *episodic* aspects of our corporeal knowledge. A body-based-action-annotation-system (G-ABAS) and Interpretative

Phenomenological Analysis methodology is applied for the first time to gesture (G-IPA). These tools facilitate fine-grained corporeal dynamic and narrative gesture feature analyses.

Phenomenal data reveal that these young people have latent resources, capacities and capabilities that they can express corporeally. Iteration of these interpretative findings with the Cognition-in-Action framework allows for the inference of processes that may underlie the strategies they use to achieve such social-motor-cognitive functions. In summary, their Cognition-in-Action is *brought-forth, carried forward* and has the potential to be *culturally embodied*.

The utility of C-i-A framework lies in its explanatory power to contribute to a deeper understanding of child gesture. Furthermore, I discuss and illustrate its potential to influence practice in the domains of pedagogy, rehabilitation and the design of future intimate, assistive and perceptually sensitive technologies. Such technologies are increasingly mediating our social interactions. My work offers an ecologically valid alternative to tradition conceptualization of perception, cognition and action. My thesis contributes both new knowledge and carries implications across the domains of movement science, gesture studies and applied participatory performance arts and health practices. (586)

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Dedication

*To all the children unborn, born and those no longer with us,
who allow me a unique insight into their real and imaginary world(s)*

*To Sophia & Alexander
for the generosity of their love and reflections on gesture.
They continue to be my constant inspiration.*

For my partner, mother, father and brothers

*My philosophical and scientific journey set out to explore both the science and art of
gesture. I hope that through sharing my passion and fascination of human corporeal
action, I have contributed some new knowledge and caused some level of infection in
the people who have joined me.*

List of Acronyms

CP	Cerebral Palsy
BST	Biological Systems Theory
C-i-A	Cognition in Action
CGC	Child Gesture Corpus
AE	Action Entity
GAA	Gesture-As-Action
GAE	Gesture Action Entity
P-GAE	Procedural Gesture Action Entity
S-GAE	Semantic Gesture Action Entity
E-GAE	Episodic Gesture Action Entity
GA-EA	Gesture As Executed Action
GA-SA	Gesture As Simulated Action
SSMI-CP	Severe Speech and Motor Impairment due to Cerebral Palsy
NAT	Neuro-atypical
NT	Neuro-typical
PTI	Physicality and Tangibility of Interaction
G-ABAS	Body- Gesture-Action-Based-Annotation-System
IPA	Interpretative Phenomenological Analysis
G-IPA	Gesture-based IPA
SKIP	Spatial Kinaesthetic Interaction & Intelligence Profile
SM	Sense-making
AAC	Augmentative and Alterative Communication
BST	Biological Systems Theory branch of General System Theory (GST)
DST	Dynamic Systems Theory e.g. motor development; for mathematical instantiations referred to as Dynamical Systems Theory
DFT	Dynamic Field Theory, mathematical formalization of continuous interactions features, e.g. movements, cognitive decisions, perceptions

Chapter 1 Introduction-Research Context and Motivation

Human Interaction The status quo

Traditional theories and models of human interaction are typically based on conceptual frameworks that have the notion of representation at their core. They argue that our human abilities to understand our own and the action of others rely on mechanisms of: inference, prediction, prospection, imitation, emulation or simulations; specifically, of the mental state of the social ‘other’. The majority of research is, however, restricted to a limited understanding of what are clearly complex relationships. Such approaches underlie the development of theories and empirical research in wide-ranging domains including: neuroscience, developmental psychology, language and gesture studies, computer science and beyond. Of particular relevance to my thesis, is that they also significantly influence practices in medicine, rehabilitation, pedagogy and the design of technology for children.

1.1 My Journey

Alternative Bodies, Pathways and Interaction

My theoretical approach and practice is influenced by my work as a developmental biologist, an academic researcher, dramaturg¹, teacher, and cognitive academic therapist. My journey began by reflecting on the quality of interaction of children with severe speech and motor impairment due to Cerebral Palsy (CP). Cerebral Palsy is a non-progressive condition affecting motor co-ordination, posture and cognition. It is one of the most common disAbilities in childhood. Its causes lie in what are described as abnormalities that arise from trauma to the developing brain of the foetus or neonate. In terms of the medical model, a diagnosis is often sought when children do not appear to reach ‘*normal milestones of development*’.

At the neurological level, damage is identified in areas of the *basal ganglia and the cerebellum*. These structures are involved in the integration of movement and form part of the neural sub-systems associated with human reasoning and adaptive functions. There is a high level of connectivity to the neuronal structures of the thalamus, frontal lobes and prefrontal cortex.

¹ Dramaturg refers to a specialist in dramaturgy, especially one who acts as consultant to a theatre company.

Most recently, researchers who are reviewing the role of the basal ganglia in cognitive-motor interaction throughout development are considering the implication this may have for both motor symptoms and higher order deficits.

The challenges that children with cerebral palsy face are significant. The condition fundamentally affects their primary means of movement and expression. My exploratory work with children with CP revealed that they have latent motor-cognitive capacities which they can use both to express themselves and interact socially with others.

This work revealed that children's corporeal experiences can '*bring forth*' and '*carry-forward*' latent capacities which are in stark contrast to existing reports of their interaction abilities. Reports typically come from: paediatric medical diagnosis, evaluations from physical, occupational and speech therapists, the experience of teachers, parents/carers and importantly the beliefs of children themselves.

These early reflections continue to fuel a questioning of traditional, representational models of interaction. I argue that critically, these models lack the power to explain or help us gain a deeper understanding of the latent capacities of these children.

1.2 My Thesis

An Argument for Biological Social Beings

My thesis presents a concept of interaction driven by the notion of intentionality, more specifically, the *intentionality of action*. This intentionality of action is fundamental to our interactions as biological social beings. This conceptual approach places the emphasis on 1st person experience and examines the 2nd and 3rd person perspectives. My empirical study focuses on children's gestures. Gestures can be considered as either *overt action* phenomena that are externalised and made visible or as *covert* action that is a non-visible phenomenon. Scientific arguments are put forward that gesture repertoires can provide a window into a child's *corporeal cognition* and thus place the '*Action-Ready-Body*' centre stage.

Gesture-An Ephemeral Phenomenon

My thesis challenges traditional, representational conceptual frameworks that underlie our contemporary understanding of gesture. In this thesis, the scope of gesture is extended and described as:

any unfolding, ephemeral intentional action that carries salience within a dynamic, self-regulating, autonomous, non-linear system.

Intentional actions can provide humans with an extensive repertoire of expressive gestures. Gestures can be considered corporeal phenomena that have the capacity to enhance our interactions; they are both continuous and dynamic. Gestures are both critical to and enrich socialization. They unfold within a variety of environments that are populated by intentional agents. I describe such environments as: *ecologies of interaction*. The study of how children in particular develop their abilities to integrate into such complex environments provides an opportunity to re-examine their gestural capacities. As organisms we are both intimately a part of and in turn influenced by our social and physical environments.

These ecologies of interaction unfold in three time-space dimensions: the *veridical*, i.e. physical space-time; the *imaginary*, i.e. invisible or covert space-time and the *hybrid*. I introduce the term hybrid to describe environments that encompass both cognitive and material artefacts. Such artefacts extend the nature of our interactions and can include tools and everyday objects. In the imaginary sphere these artefacts, i.e. imaginaries, may be bound to the individual or shared socially with others, e.g. societal beliefs, the unexpected or the futuristic. In contemporary life these artefacts may include interactive digital technologies, such as those used for communication, education, edutainment, rehabilitation, creative practice and performance.

My definition of gesture clearly goes beyond conventional contemporary conceptualizations of gesture that largely envisage gesture as a phenomenon ‘*in-the-service*’ of language. I would argue that contemporary studies should treat gesture as complex corporeal phenomena that unfold dynamically within such ecologies of interaction. These interactions carry significance for the individual (intra-perspective), between social others (inter-perspective) and for the social others i.e. artefacts (inter-objectivity).

Why neuro-atypical gesture? – The research gap

Children with *cerebral palsy* offer a unique opportunity to re-think gesture in a neuro-atypical population. This is an area where there has been a paucity of both interdisciplinary and multi-dimensional research on either the gestural or cognitive potential of children. My thesis sets out to re-consider the nature of their physical, emotional and intellectual interactions with the world. This is achieved in part through an in-depth qualitative analysis of the gestural capacities of children.

The work of this thesis focuses on children who are most severely speech and motor neuro-compromised. They present as having a limited number of controlled movements that

can be described as conventional gestures, e.g. upward/downward eye movement for yes/no, gross head movement for nod (yes)/head shake (no), gross movement to hit a target on a communication board or mechanical switch to operate a toy or push a joystick.

The movement profiles of these children are often globally described as '*writhing and chaotic*'; they have difficulty with muscle tone, movement and motor skills development. They are reliant on their parents/carers for their daily needs as their independent everyday activities are extremely restricted. Their challenges can be complex and may also involve cognitive, hearing and visual impairments. These children are often quadriplegic wheelchair users. Under the International Classification of Functioning, Disability and Health for Children and Youth (ICF-CY) these children are classified as having motor abilities tending towards level V. Level V is described on the Gross Motor Function Classification System (GMFCS)² for cerebral palsy as:

Physical impairment: restricted voluntary control of movement and the ability to maintain anti-gravity head trunk posture. All areas of motor function are limited. Functional limitations in sitting and standing are not fully compensated for through the use of adaptive equipment and assistive technology. At level V, children have no means of independent mobility and are transported. Some children achieve self-mobility using a powered wheelchair with extensive adaptations.

External aids are needed for communication as their speech is often difficult to understand, i.e. they have a dysarthric³ speech disorder. Communication is achieved by using alternative systems termed Augmentative and Alternative Communication (AAC) devices, e.g. letter selection from a board using eye gaze or technology with digital speech output. Children with this level of motor compromise cannot access traditional keyboard or tablet interfaces directly with their fingers. They are often educated in special schools with individualised learning programmes. As with their motor profiles, the cognitive profiles of the children are heterogeneous.

However, on a cautionary note, levels of competencies cannot necessarily be inferred by the level of neurological brain damage.

² See www.motorgrowth.canchild.ca/en/GMFCS/resources/GMFCS_English.pdf for more details.

³ Dysarthria is a motor speech disorder. The muscles of the mouth, face, and respiratory system may become weak, move slowly, or not move at all after a stroke or other brain injury. The type and severity of dysarthria depend on which area of the nervous system is affected, www.asha.org/public/speech/disorders/dysarthria.

In fact, leading clinicians in the field warn against predictive diagnosis and prognosis based on such data alone. Although it is stated that generally speaking the:

'more severe structural changes mean more severe motor and cognitive neurological disability'... 'other individuals may have equal cognitive and motor severity with near normal MRI'... 'or individuals with severe structural changes on the MRI' ..and. 'cognitively normal....' has... 'triplegic patterned CP but ambulates'. (Miller, 2007 p.48)

Miller goes on to caution physicians: *'not to develop prejudices concerning an individual child's function based on imaging studies'* (ibid, p.48).

The most recent World Health Organization guidelines for working with people with disability highlight the need for further interdisciplinary research. Importantly, for the aims of my thesis, they make recommendations for a more holistic, rather than a *deficit model* of intervention approaches. However, established medical/clinical models of intervention are largely focused on working towards improving functional motor ability, e.g. in physiotherapy and occupational therapy. Similarly, in speech and language therapy the focus is largely on learning the use of AAC devices.

Cognition-in-Action

Fundamental to the biological perspective that influences my work is the notion that all living organisms are autonomous, bounded entities driven to self-replicate and influenced by their environments; this can be described as an *autopoietic system*⁴. Within a Biological System Theory (BST) framework - *knowledge* can be equated with notions of *cognition* and *action* equated with *knowledge*. These notions support the theoretical foundation for re-thinking gesture. I propose the construct: *Cognition-in-Action* (C-i-A).

Building on my initial definition of gesture, any child's gesture can thus be considered an *open, bounded, autonomous, self-regulating* system that both expresses characteristics of *non-linear dynamics* and is influenced by varying *constraints*. Set within the context of attempting a deeper understanding of child gesture, I introduce the term the *Action-Ready-Body* to reflect the corporeal focus of my work; *corporeal* is defined as: *that has materiality, affecting or characteristic of the body*. Within this I re-examine the notion of *enactive gesture*, where

Enaction is defined as: *one of the possible ways of organizing knowledge and one of the forms of interaction with the world*.

⁴ Autopoiesis is a term proposed by Maturana and Varela (1974).

In my thesis enactive gesture is instantiated during ludic⁵ interactions in terms of *corporeal performance*.

The proposed construct of *Cognition-in-Action* encompasses both the notion of corporeal agency and the concept that interactions happen within a biological system that creates meaning. In the subsequent chapters of my thesis I go on to present more detailed arguments from the biological sciences and philosophical domains for the consideration of *knowledge-as-action*.

From a philosophical perspective, I am inspired by the work of the philosopher, Merleau-Ponty, who argued for social cognition that is both *non-representational* and *intercorporeal*. He argues for the primacy of the body in perception (Merleau-Ponty, 1962) i.e. corporeality.

This notion of corporeality is described in terms of a life of consciousness-*cognitive life*, (author's italics) where:

'the life of desire or perceptual life – subtended by an 'intentional arc' which projects round about us our past, our future, our human setting, our physical, ideological and moral situation, or rather which results in our being situated in all these respects.' (Merleau-Ponty, 1945/2005, p.157)

Of child intentionality he gives a very pertinent example when he observes:

'That is why, in their first attempts at grasping, children look, not at their hand, but at the object: the various parts of the body are known to us through their functional value only, and their co-ordination is not learnt.' (ibid, p.172)

In terms of the intercorporeality of interaction, he describes the reciprocity of his intentions and the gestures of others: *'as if the other person's intentions inhabited my body and mine his.'* He argues that there is a need to review what we mean by both communication and our perception of the 'thing'. He describes it as there being a:

'mutual confirmation between myself and others. Here we must rehabilitate the experience of others which has been distorted by intellectualist analyses, as we shall have to rehabilitate the perceptual experience of the thing.' (ibid, p.215)

Importantly, for my construct of *Cognition-in-Action*; he identifies that objects become known through perceptual experience equated with exploratory movement, i.e. embodied action.

⁵ Ludic-a term that came into use in the 1940s it describes the show of spontaneous and undirected playfulness.

This knowledge does not arise through some notion of labelling as is commonly thought. In this case he talks about a veridical object in a room-a fireplace:

'The identity of the thing through perceptual experience is only another aspect of the identity of one's own body throughout exploratory movements; thus they are the same in kind as each other. Like the body image, the fireplace is a system of equivalents not founded on the recognition of some law, but on the experience of a bodily presence. I become involved in things with my body, they co-exist with me as an incarnate subject, and this life among things has nothing in common with the elaboration of scientifically conceived objects.' (ibid, p.215).

Acts of Meaning

I go on to argue that any 'acts of meaning' can be described in terms of biologically based sense-making as *biosemiotic*⁶. These meanings are undoubtedly influenced by our neurology and unfold in what I further describe as *neuro-dynamic ecologies*⁷. The detailed neuro-dynamic aspects of the Cognition-in-Action conceptual framework do not form part of this thesis.

These aspects of meaning-making for humans and some mammalian species have relevance not only in the *moment-to-moment* or microgenetic level but also carry significance at the *developmental* (ontological) level. They can be considered to illustrate the phenomenon of *cognitive adaptation*⁸ that supports knowledge transformed within evolutionary (phylogenetic) timeframes of human culture. Thus, I provide a description of human culture as: *the evolution of the interplay of social-motor-cognitive intentional agents, within and across their material and imaginary worlds*. My approach is illustrative of theories that advocate a distributed framework for understanding human culture.

The C-i-A Architecture

To aid understanding a simplified schematic of the architecture of the proposed C-i-A conceptual framework is presented in Figure 1.1. It is proposed as a descriptive, non-computational biological feature-based system for re-thinking gesture. This figure shows the relationship between the corporeal self as an *Action-Ready-Body* with capacity to express intentional action as embodied, extended and enacted gesture to reveal latent resources and structures. The *self*, indicated by the larger ellipse shape is dynamically connected (indicated

⁶ Biosemiotics is concerned with the study of the production of signs and codes in the biological realm. I will later elaborate on the notion of 'Umwelt' proposed by Uexküll (1909) see also Panayi (2012).

⁷ See Panayi (2012)

⁸ Cognitive Adaptation is a term used by Merlin Donald (2007 and 2010) in his descriptions of three stages of the evolution of culture and cognition.

by the double ended arrows) to the *social other* (smaller ellipse) and the other as *artefact* (hexagonal shape). The framework focuses on the exploration of intentional action as both capacities, indicated by the inner smaller bounded box, and constraints within a biological system indicated by the larger bounded box. A Biological System Theory approach is proposed as the best candidate to examine ecologies of interaction that are embedded in biosemiotic and neuro-dynamic contexts.

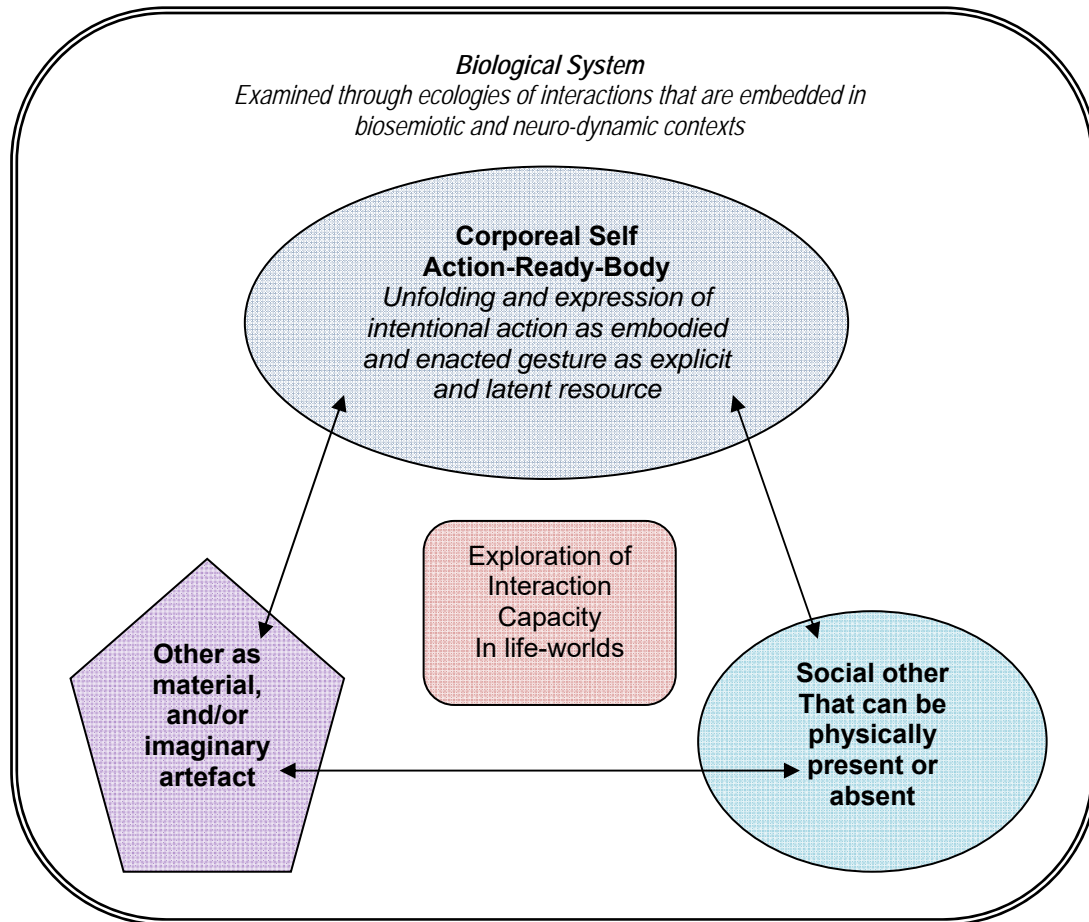


Figure 1.1 A simplified schematic of the Cognition-in-Action conceptual architecture. This thesis presents a descriptive non-computational biological feature based conceptual framework for re-thinking gesture as Cognition-in-Action. A Biological Systems Theory approach is proposed as the best candidate for the theoretical framework.

A Theoretical Synthesis and Empirical Study

I present an interdisciplinary theoretical synthesis that brings together two perspectives: biological and the phenomenological. The advantage of using a Biological Systems Theory approach is that it allows for the complexity of the system to be considered in a more systematic and effective manner. It supports consideration of evidence both from within and across the domains of *Philosophy, Science and Technology*, including *Practice*.

The phenomenological perspective allows for the qualitative analysis of children's lived-experiences in relation to their gestural capacity within their ecologies of interaction – their '*life-worlds*'. It can be structured for the systematic analysis of specific phenomena to reveal emergent themes. This phenomenological perspective is also supported by an empirical study.

The empirical study presented in my thesis explores the nature of children's *intercorporeality* as they engage in playful enactive interactions. These ludic interactions generate meaning through intersubjective experience. They are considered to be both appropriate and ecologically valid. The ecology of interactions allows for an exploration of how *pretence* may be influenced both by the nature of intersubjectivity and social cognition within the context of levels of child engagement. It is within this framework of phenomenological, participatory experience that the intentionality of corporeal action is interpreted.

These gestural experiences have been captured on video and form the bases of a unique Child Gesture Corpus (CGC). The corpus contains gesture exemplars from both neuro-atypical and neuro-typical children. An in-depth analysis of three case study exemplars from neuro-atypical children with cerebral palsy is presented in this thesis. The relevance of case study methodology to the aims of the thesis is summarised in the following five points:

- *It typically provides ecologically valid data.*
- *It contributes to a deeper understanding of the phenomenon being explored.*
- *It allows for different levels and where appropriate different methodologies of analysis to be applied at these different levels, e.g. system theory to support theoretical inquiry and case study methods to support the empirical study.*
- *It supports theory building and the refining of the Cognition-in-Action construct by highlighting individual changes and process that can be applied to intervention, e.g. gesture capacity of children, particularly those with severe speech and motor impairments due to cerebral palsy.*
- *It is financially viable in circumstances where research budgets are limited.*

The nature of the empirical study also necessitated the development of an annotation tool. This qualitative action-feature based tool has a novel ontology that enables analysis of both *corporeal dynamics* (procedural features) and *corporeal narrative* (semantic and episodic features) of child gesture. The tool significantly extends existing gesture study annotation methodologies.

Interpretative Phenomenological Analysis (IPA) is a methodology that allows for phenomenological, interpretive (hermeneutic) and idiographic data to be analyzed together for a specific phenomenon. It is the preferred candidate analysis method as it is consistent with the conceptual framework. It comes from text analysis but was adapted for the first time in my thesis for the video analysis of the neuro-atypical physically expressed gestures of children, henceforth referred to as G-IPA. This methodology allows for the synthesis of both the individual, i.e. *emic* data and *etic* data, i.e. derived from research observation and interpretation. These data sets are used to instantiate aspects of the Cognition-in-Action framework. Used iteratively these tools support an explanatory mechanism of access and control of enaction.

The rationale for coupling a *case study* methodology with a Biological System Theory (BST) approach lies in its robust capacity to consider multiple factors while considering the system as a whole. The limitation of case methodology is undoubtedly that findings cannot be generalised to larger populations without future studies.

However, the conceptual design of the framework can be used inclusively for both neuro-atypical and neuro-typical child gesture, although only neuro-atypical exemplars are analysed in my thesis. The utility of the conceptual framework in terms of its generalizability lies in its future use and as a precursor to larger studies. The validity of the use of case study methodology in pedagogy, clinical practice and technology design is discussed in subsequent chapters of the thesis. The major advantage of applying interdisciplinary methodologies is that they can be used to build new knowledge that can influence theories and affect changes in practice.

Importantly, I put forward arguments that conventional frameworks are lacking since they do not have the capacity to be inclusively. That is to explain both neuro-typical and neuro-atypical gesture, without recourse to deficit models of perception, cognition and action. Furthermore, they lack the explanatory power to deal with the dynamic nature of the system from which gesture evolves. In contrast, both the tools and the conceptual framework that I

have developed and applied can be used independently for qualitative research or used to inform quantitative studies, e.g. in the fields of health, gesture or technology design research and practice. This can be done without recourse to such deficit models of interaction.

1.3 Thesis Aims and Objectives

My earlier exploratory work with children focussed on pedagogy, technology design and performance art. It was here that I began to identify the need to consider the nature of both procedural and narrative aspects of child gesture, specifically, how motivation and engagement affected the quality of interaction and the relationship that could be developed between co-participating inter-actors.

Aim 1 To develop a conceptual framework for re-thinking the gestures of neuro-atypical young people, which is non-traditional and non-representational: Cognition-in-Action

The first aim proposes the construct of *Cognition-in-Action (C-i-A)* as means of exploring conceptual frameworks that do not rely on traditional representational explanation for understanding perception-cognition and action. Theoretical frameworks have the advantage of being able to condense and provide coherence to bodies of related knowledge. Equally, the influence of our practice contributes to the development of our theoretical models. This links the first aim to the second and third aims of my thesis.

Aim 2 To develop qualitative analytical tools for the annotation and interpretation of gesture that can be applied inclusively to both neuro-atypical and neuro-typical young people

The second aim addresses the lack of annotation and interpretation tools that can be applied inclusively to both neuro-atypical and neuro-typical child gesture.

Aim 3 To consider the conceptual framework in terms of its theoretical implications and practical application

The third aim considers the conceptual framework in relation to evidence from an empirical study of neuro-atypical child gesture. It discusses the utility of the framework in terms of future practical application and theoretical implications. It should be noted that such models or frameworks are able to describe, interrogate and simulate aspects of complex ideas and processes. The mathematical simulation of the dynamic aspects of the conceptual framework is not part of the work of this thesis. This forms part of the ongoing research challenges.

Objectives

The following objectives addressed my aims, namely:

Objective 1: *To critically review existing frameworks and models of medical practice in relation to cerebral palsy children's action and gesture*

The critical review presented in Chapter 2 examines extant literature in the domains of medical and clinical practices, neuroscience and linguistic models of gesture. This chapter identifies the research gaps at both a theoretical and practice levels.

Objective 2: *To develop a theoretical framework that can support the re-conceptualization of emergent intentional action by children expressed as gesture*

I introduce the Biological System Theory motivated conceptual architecture for the Cognition-in-Action framework, presented in Chapter 3

Objective 3: *To outline an inclusive methodology that has the capacity to investigate neuro-atypical and neuro-typical gesture within the same paradigm*

In chapter 4 I outline the methodology that facilitated young people's contributions to the Child Gesture Corpus. I show how it underpins the analyses of exemplars in the empirical study.

Objective 4: *To identify, develop and adapt qualitative tools to support the annotation and interpretation of bodily expressed child gesture.*

I address the challenge and justify the development of novel action body-based gesture annotation system (G-ABAS) and Interpretative Phenomenological Analysis (G-IPA) tools for use with neuro-atypical cerebral palsy gesture data. These are presented in chapter 5.

Objective 5: *To examine what gestures reveal about children's corporeal Cognition-in-Action*

In Chapter 6 I present the first level of interpretative analysis that examines both corporeal dynamics and corporeal narrative features.

Objective 6: *To consider the relationship of the underlying enaction subsystem*

In Chapter 7 I present the second and third levels of interpretative analysis where I examine the complexity that necessarily underlies the enaction of gestures by cerebral palsy children.

Objective 7: *To identify the practical utility of the gesture-based annotation and interpretative phenomenological analysis tools within the Cognition-in-Action conceptual framework*

In Chapter 8 I discuss the utility of the qualitative tools I have developed for the annotation and analysis of child gesture within the C-i-A framework for both practitioners and researchers.

The work of my thesis is guided by these aims and objectives. They serve to structure my contribution to the research gaps that have been identified. I successfully use a qualitative

mixed methods approach to develop a deeper understanding of the complex nature of cerebral palsy child gesture within a dynamic system.

1.4 Overview of the thesis

In Chapter 2, I present my literature review. I discuss the scope, inclusion criteria and stages of the review. Three sections review medical models and clinical practice in relation to cerebral palsy; models of action control and models of gesture. Each section ends with a summary. The chapter ends with an executive summary.

In Chapter 3, I introduce my approaches to re-thinking gesture I discuss gesture as a biological system. I then move on to discuss models of corporeal action in relation to gesture. The final section introduces my *Cognition-in-Action* framework informed by my theoretical synthesis. The chapter ends with a summary.

In Chapter 4, I introduce the methodology that underpins my empirical study of child gesture in the context of the challenges of gesture studies in ecological setting and my ludic paradigm. The second section presents my empirical research plan, it includes a description of the Child Gesture Corpus, the selection criteria and data for my co-participants, I provided details of my ludic interaction protocols for three conditions. Condition A an adapted charade game, the co-constructive narrative interaction (Condition B) and the manipulation of artefacts (Condition C). The chapter ends with a summary.

In Chapter 5, I introduce the background to the development of two tools. The body focused Gesture-Action-Based-Annotation-System (G-ABAS) is presented in the context of the challenges of video analysis of neuro-atypical gesture and the challenges of annotation more broadly. I also included a discussion of issues around the classification and description of communication, movement, and cognition and gesture of children including those with atypical profiles. The G-ABAS ontology is summarised. I introduce Interpretative Phenomenological Analysis method, typically use with text, that I have adapted and applied to gesture for the first time (G-IPA). The chapter ends with a section on the limitations, advantages and potential applications of these tools and a summary.

In Chapter 6 and 7 I present the analyses of selected neuro-atypical gesture exemplars from young people with severe speech and motor impairment due to CP who contributed gesture for Condition A the adapted charade game and Condition C the Manipulation of Artefacts. Chapter 6 focuses on the analyses of *corporeal dynamic* features in the context of the C-i-A framework. I discuss the potential for scoring, evaluation and validation of the tools

in these interaction scenarios. The chapter ends with a summary of findings of corporeal dynamic features for case study 1 and 3.

In Chapter 7, I focus on the analyses of *corporeal narrative* features in the context of the C-i-A framework. Exemplars are presented from Condition B, the co-constructed narrative interaction ‘Cowboy goes to Town’ (Case Study 2) and Condition C, the Manipulation of Artefacts (Case Study 3). Summary interpretative findings are presented that discuss sense-making, space, performance strategies (including improvisation) and integration capacities of these young people. I discuss how the G-ABAS and the G-IPA tools can be applied in pedagogic, clinical and design settings. This is done in the context of the Spatial Kinaesthetic Interaction Intelligence Profile (SKIP). The capacities of these young people are discussed in terms of the corporeal gestural sphere, situated practice guidelines and the concepts of gestural flow and slow process. The chapter ends with a summary.

My discussion is presented in Chapter 8 I revisit the significant research gaps that I have identified and their implications. I review my work plan and revisit the C-i-A framework in the context of my key findings and outcomes. The last section illustrates how aspects of the C-i-A framework can be instantiated. The chapter ends with a summary of the significance and implications of my findings.

I conclude my thesis in Chapter 9 discussing how I met my objective. I show how my theoretical conceptual framework, tools analyses and interpretations have contributed new knowledge to the field of child gesture studies and more broadly to the domain of cognitive science. The chapter ends with identify areas of future work in the context of two specific open questions.

	AIMS AND OBJ	OBJ 1	OBJ 2	OBJ 3	OBJ 4	OBJ 5	OBJ 6	OBJ 7
CHAPTER 1 INTRODUCTION <i>Research Context and Motivation</i> <i>My Journey, My Thesis</i> <i>Aims and Objectives</i>								
CHAPTER 2 LITERATURE REVIEW <i>Critical review foci, inclusion criteria and stages</i> <i>Movement Science Medical Models, Clinical Practice & CP</i> <i>Models of Action Control, Models of Gesture & Alternatives</i>	↓							
CHAPTER 3 RETHINKING GESTURE <i>Gesture as a Biological System</i> <i>Cognition-in-Action Architecture Constructs, Structures and Tools</i> <i>Action-Ready-Body Ecology of Interaction</i>	↓							
CHAPTER 4 METHODOLOGY <i>Child Gesture Study Context and Challenges</i> <i>Empirical Study Research Plan</i> <i>The Corpus: Ludic Interaction Scenarios – Charades, Stories and Things</i>	↓							
CHAPTER 5 TOOL DEVELOPMENT <i>Body-Based Gesture Annotation G-ABAS Ontology</i> <i>Gesture based Interpretive Phenomenological Analysis G-IPA Questions</i> <i>Limitations, Advantages and Potential Applications</i>	↓							
CHAPTER 6 G-ABAS ANNOTATION AND LEVEL I and II G-IPA ANALYSES <i>Corporeal Dynamics Feature Charades and Manipulation of Artefacts</i> <i>G-ABAS and G-IPA Potential for Scoring, Evaluation and Validity</i> <i>Summary Interpretative Findings and C-in-A Framework</i>	↓							
CHAPTER 7 G-ABAS ANNOTATION AND LEVEL III G-IPA ANALYSES <i>Corporeal Narratives Stories and Things</i> <i>Summary Interpretative Findings and the C-in-A Framework</i> <i>G-ABAS and G-IPA Application in Pedagogic, Clinical and Design Settings</i> <i>Gestural Flow and Slow Process</i>	↓							
CHAPTER 8 DISCUSSION <i>Significant Research Gaps and Implications</i> <i>Work Plan</i> <i>Revisiting C-i-A and Instantiating aspect of the Framework</i> <i>Summary of Significance of the Work and Implications of Findings and Outcomes</i>	↓							
CHAPTER 9 CONCLUSIONS <i>Meeting my objective The Why? From Whom? and How?</i> <i>Contribution to knowledge, Timeliness and Implications</i> <i>Future Work</i>								

Chapter 2 Literature Review

2.1 Background

This critical review places my research with reference to the contemporary extant literature in the context of movement sciences, gesture studies and applied and participatory arts practices. My thesis focused on exploring the nature of corporeal expressivity in young people with severe speech and motor impairment due to cerebral palsy (SSMI-CP). Due to the interdisciplinary nature of my work I propose the use of an overarching Biological Systems Theory framework which allows for literature to be considered both within and across the domains of: *Philosophy, Science and Technology*, including practice. In terms of practice, I consider work in the medical, applied participatory arts and technology arenas. To provide a starting point for the re-thinking of gesture, I revisit both models of action and models of gesture. Where relevant I make reference to historical work.

This synthesis provides a foundation for the aims of my thesis. I discuss conventional models of medical practice, models that underpin our thinking of perception-cognition and action in the neuroscience and linguistics domains, including gesture studies. I also highlight the potential of sensing technologies to facilitate change. I identify the research gaps in both our understanding of corporeal gesture and the nature of intentionality in children with SSMI-CP. This approach is supported by leading clinicians who have identified the need for not only new ideas but also protocols to support the development of our work into the 21st century.

I begin the chapter by summarising the review foci (Table 2.1), inclusion criteria (Table 2.2) and stages of the review (Figure 2.1). The critical review is presented in three main sections. The first section 2.2 deals with literature in the *Movement Sciences*. This section re-examines *aetiology; conceptualizations of disAbility, classification; activity, capacity, capability and performance*. Consideration is given to *allied participatory performance art and technology enhanced capture of movement*. The implications for *intervention and assessment* are discussed prior to *summary* in section 2.1.4

Section 2.3 reviews *Models of Action in relation to control, neurology of cerebral palsy and neuroscience technologies*. *Motor action is considered in terms of features including cognition, imagery, imitation and social interaction*. Section 2.4 revisits *Models of Gesture*. I consider traditional aspects of gesture, such as iconicity, metaphor and metonymy, and space

within my gesture-as-performance construct and the C-i-A framework. These aspects are then considered within the language vs gesture debate and set against alternative perspectives. The chapter ends with a *summary* in section 2.4.

Review Foci	Objective
<i>Identified the research gaps in our understanding of neuro-atypical child gesture</i>	1
<i>Motivated the theoretical underpinnings and development of the Cognition-in-Action conceptual framework</i>	2
<i>Supported the development of the interaction paradigm that underpinned the contributions of cerebral palsy children to Child Gesture Corpus</i>	3
<i>Supported identification of candidate qualitative methods for the annotation and interpretation of neuro-atypical child gesture data</i>	4
<i>Informs the feature based examination of children's corporeal cognition and enaction subsystems</i>	5 and 6
<i>Validates the need for alternative conceptual frameworks and practical tools to support our understanding of neuro-atypical child gesture</i>	7

Table 2.1 Critical Review foci in relation to thesis objectives

2.1.2 Inclusion Criteria

Literature for inclusion was selected based on the five criteria, which are summarised in Table 2.2. The literature was restricted where possible to work that examined child gesture in ecologically valid settings: children aged between 6-18 years classified at GMFCS levels IV-V and MACS IV-V. Preference was given to work informed by child data. The review considered clinical practices that highlighted the challenges of working with cerebral palsy children in rehabilitation settings. The review was restricted to selected literature from physical, occupational, speech and language therapies and applied performance arts practices.

I considered theoretical frameworks and empirical work that could both inform and illustrate the timeliness of the Cognition-in-Action conceptual framework. Preference was given to conceptualizations that use dynamic theory. Gesture models that focus on co-speech gesture was restricted. Models of action control are also considered and placed within the movement science domain. In terms of the challenges of elicitation and annotation of child gesture, work was included that could support novel body-based annotation of gesture. Alternative perspectives of embodied action that are influenced equally by performance art and anthropology were considered, as these informed a deeper understanding of the corporeal nature of expression.

Only selected technology-based interventions in terms of motion capture (including use in rehabilitation settings) and the design of future technology platforms were included. Finally, research based on reviews or systematic reviews was given priority for inclusion over individual studies.

Criteria	Explanation	Objectives
1	Child gesture studies that included neuro-atypical children with severe speech and motor impairment due to cerebral palsy, within the age range of the selected exemplars presented in the empirical study, i.e. 6-18 years. Where possible at level IV- V using the ICY classifications.	1
2	Theoretical frameworks and empirical work that could inform the enactive conceptual framework for Cognition-in-Action. Preference was given to those that focused on: a) Child data. Gesture models that focus on co-speech gesture were restricted. b) Models of action control c) Alternative perspective of embodied action, including performance art and anthropology	2/3/4/5
3	Work that highlights or could contribute understanding to the challenges of elicitation and annotation of child-embodied gesture in ecologically valid settings, i.e. ludic interactions, school room, and some clinical settings	3/4
4	Clinical practice in rehabilitation settings that highlight the challenges of working, with cerebral palsy children. Only selected literature for physical, occupational and speech and language therapies. Selected technology-based interventions and the design of future technology platforms were also included.	1/7
5	Research that is based on reviews or systematic reviews was given priority for inclusion over individual studies	All

Table 2.2 Inclusion Criteria and explanation in relation to thesis objectives

2.1.3 Stages of the Review

Three stages of the review and issues are summarised in the schematic in Figure 2.1. The figure schematic summarises: the origins and definitions of cerebral palsy, the focus of the majority of the research, the nature of existing models of action and gesture, the paucity of corporeal gesture research that focused on young people with CP and the need for more holistic approaches.

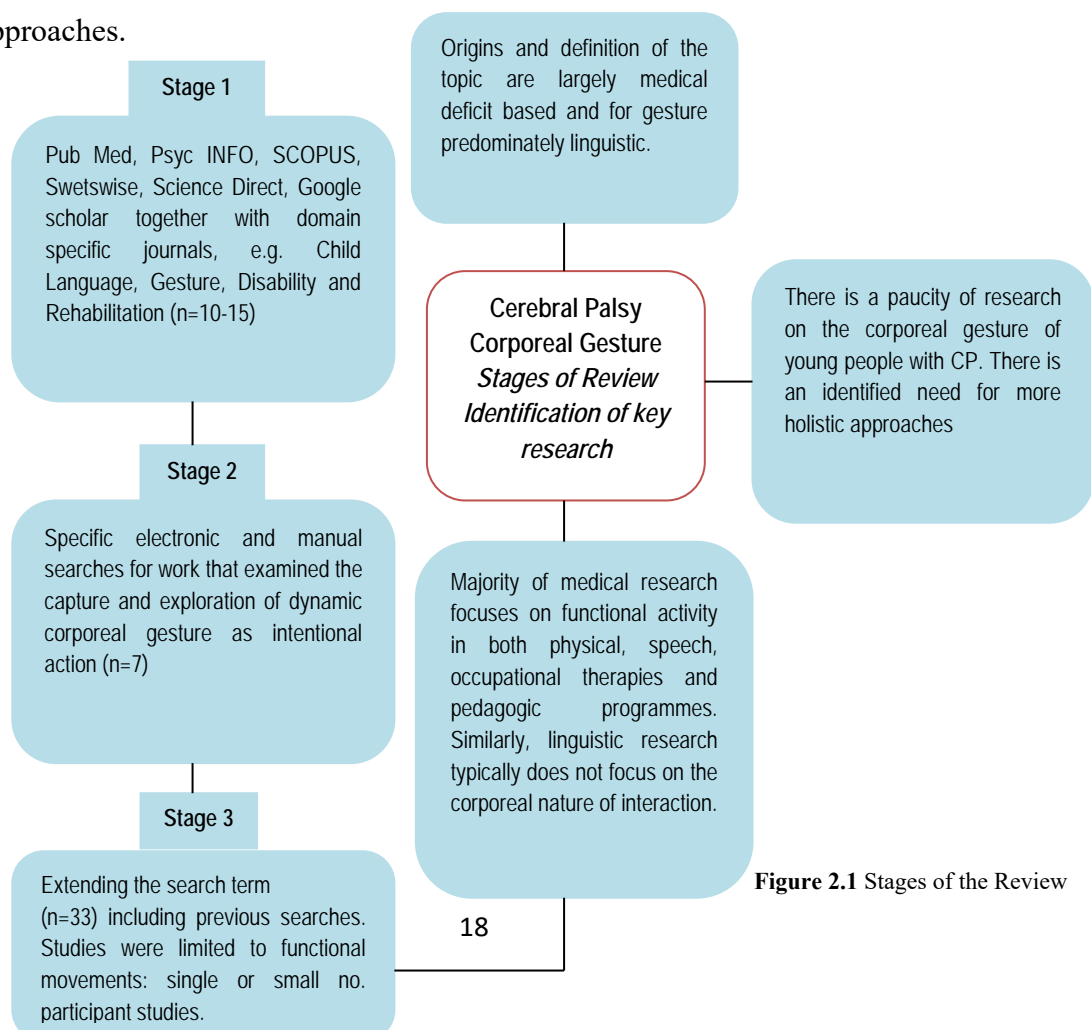


Figure 2.1 Stages of the Review

First stage Electronic database searches

Stage 1 examined the state of the art of current medical practice in relation to children with cerebral palsy. Electronic database searches were carried out. These included: *Pub Med, Psyc INFO, SCOPUS, Swetswise, Science Direct, Google scholar*, together with domain specific journals, e.g. *Child Language, Gesture, Disability and Rehabilitation*. These choices were informed by my practice knowledge of medical rehabilitation, pedagogy and performance art. I attempted to limit searches to those that involved cerebral palsy children. Keyword search phrases included:

'child gesture studies enaction paradigm play' with the extract term *'ecologically valid'*, *'cerebral palsy'*, *'corporeal'* but without such terms as in *infant – toddlers -speech – literacy - sign language - deaf -robotics -autism -animal -workplace -violence –abuse*.

Typically, 10-15 studies were found, of which very few fitted all five inclusion criteria, see (Table 2.2). The remainder have been included in the discussion sections of the ensuing chapters where relevant.

Second Stage Electronic and manual searches

Stage 2 involved more specific electronic and manual searches for work that examined dynamic corporeal gesture as intentional action, i.e. not those actions that use A or B choice and/or key press/switch selection paradigms. This search was restricted to dates between 1996 and the present and to children of 6-18 years. For a previous review of child 3D gesture and SSMI-CP prior to 1996, see Roy (1996). My literature search found a limited number of gesture studies, e.g. Pub Med (7 items). Few studies consider the potential use of imagery in children with cerebral palsy. An additional search in Springer covering 1996-2018 including the terms:

'cerebral palsy, whole body movement, children, corporeal expression gesture and children' and various exclusion terms,

revealed 31 results, of these 31 items, 7 were considered to inform the disability culture, performance and technology generally. Only one, Maconochie (2018) focuses on embodied participation of young disabled children; two papers by Anaby et al (2015/2017) focus on the nature of participation in children and in the context of current rehabilitation practices. Imms et al. (2016) propose participation both as a means and an end through a conceptual analysis of processes and outcomes. Musgrave (2016) examines narratives by disabled adults in the context of digital citizenship; one by Overboe (2012) discusses philosophical issues that relate to impairment and impersonal singularities in the context of disability and social theory.

In the medical sector, an edited work by Panteliadis (2018) on multidisciplinary approaches to Cerebral Palsy and has a section on *non-medical intervention* which gives a good summary including comments on intervention efficacies. Although two contrary *whole body interventions* - Bobath and Vojta are mentioned, they are identified as being based on similar theoretical ideas about motor control and neurological development and both exploit reflexive movement. These ideas date from the '40s and '50s and are being reconsidered in the light of more recent knowledge about motor learning. The influence of practices by dynamic systems theory is discussed, although its development in application is constrained by the limitations of existing practices, which still largely focus on *remediation of impairment*. It should be noted that there is a lack of any mention of alternative or emerging potential interventions, the word *gesture* let alone *corporeal expression* is not mentioned.

The need for measures to evaluate the everyday activity of children with CP was identified in a systematic review as early as 2008 by Harvey et al. It stated in its conclusions that '*a range of measures is required to evaluate activity, and assessment should be tailored to the individual needs of the children with cerebral palsy*'. Research by Onogi et al (2017) compared scaled scores of children with CP using the PEDI (Paediatric Evaluation of Disability Inventory) instrument. Significantly, they concluded that '*difficulty levels of functional skills will be set so they are adapted to the abilities of children with CP*'. Of particular interest to my research is that they found a plateau in the age band of 4-6 for children with level IV and V motor involvement, i.e. severe paralysis. However, when they compared this to self-care and social function there were some increases thereafter. The authors suggested that this provides a window of likely improvement, significantly '*after motor functions has reached a target level*'. They go on to suggest the need for '*rehabilitation approaches to encourage such skills*' (p.42).

Such findings further endorse the timeliness of my research and the potential for C-i-A framework and tools to be used as an adjunct to these instruments. Part of the rationale for using the Pub Med and Springer data base was to examine any research gap in relation to the potential clinical, habilitation practice, cultural/philosophical issues and technology design applications in the context of my work.

Third Stage extending the electronic search terms

Stage 3 used terms including *cerebral palsy*, *VR* and *neural plasticity*, which revealed 33 main items and included the relevant items from the first search. However, the majority of studies involving clinical practice models aimed at investigating rehabilitative functional

movement of upper and lower extremity and gait, i.e. movement re-training. For systematic review, see Chen et al. (2018). An example of non-immersive rehabilitation VR with application in the neuroscience domain more broadly is provided by Esfahlan et al. (2018). Such research examples illustrate the technology available for movement capture of neuro-atypical action such as that seen in children with CP. However, the studies are small, limited in scope and may also be limited by the nature of the commercial technology and mathematical analysis algorithms for complex movement data treatment. In addition, theoretical work is still required to support emerging paradigms of clinical or rehabilitation practice. A more detailed discussion of these studies falls outside the scope of this thesis.

2.2 Movement science

2.2.1 The Medical Model, Clinical Practice and Cerebral Palsy

The NICE guidelines (2018) endorse the need for early multi-disciplinary approaches not only for diagnosis and care, but also for intervention and pedagogy for young people with CP. Medical models and clinical practices could be grounded within the perspectives on sociology and disability. Goodley (2017) proposed that: *'transdisciplinary [work] between disciplines [could]...deconstruct conventional medicalization of disability'* (my brackets). Such perspectives allow for social-cultural conceptions of disablism, which is explained as: *'social imposition of restrictions on activity on people with impairment and the socially endangered undermining of the psychosocial well-being'*, *ibid.* My research proposes a re-thinking of gesture within the sociological reconsideration of disAbility. Intentionality of gesture-as-performance enables us to look not only at capacity but also capability. My research places gesture within an embodied cultural matrix allowing us to move away from normative standard and perceptions of CP movement repertoires and toward, an exploration of the potential of creative expressivity. I concur with the identified need for new ideas to challenge what are now considered naive theories and practice in the care of children with CP. I review and discuss existing medical models of motor control and the efficacy of non-drug intervention practices. The use of medical models in isolation has not only dominated, but has also had a significant impact on clinical practice. Such models are traditionally predicated on notions that promote a distinction between brain and body and, as a consequence, action and language. These models are presented together with a summary of the neurology of cerebral palsy. I identify the limitations of both reductionist models in this context. I review advanced technology- based empirical paradigms and their impact on the study of cerebral palsy.

2.2.2 Aetiology

The past two decades have seen developments in how to classify and conceptualize models of disAbility and clinical approaches. These include therapies for children and young people with Cerebral Palsy. Understanding the aetiology, risks and management of CP, although not the focus of my thesis, does have implications for my aims, objectives and future work.

Returning to a more detailed definition of cerebral palsy, the condition is described as:

'a static lesion occurring in the immature brain that leaves children with permanent motor impairment. This lesion may occur as a developmental defect, such as lissencephaly; an infarction such as a middle artery occlusion in a neonate; or as trauma during or after delivery. Because brain pathology in all these etiologies is static, it is considered CP.' p.27 Miller (2007)

Cerebral Palsy is a non-progressive neurodevelopmental disorder which begins early in life that occurred in the developing foetal or infant brain. Originally identified and formally described as a neurological disorder of movement in the 1860s, despite its prevalence, there is still some research deficiency in empirical data with regard to the cognitive skills and pedagogic performance of children with CP. This is particularly evident in the 6-18 years old age range of the young people who contributed corporeally expressive gesture exemplars to the Child Gesture Corpus.

One of the most common childhood disabilities, the incidence of CP is in the region of 2.12-2.45 per 1,000 live births. With improvements in neonatal care this incidence is increasing, recently updated to 3.9 in 1,000 births, i.e. 1 in 303 children, see Centre for Disease Control and Prevention, USA (2010). A permanent disorder, it affects the development of movement and posture, often causing activity and participation limitations. These postural difficulties and changes in muscle tone can affect either upper and/or lower limbs. Later, these issues may contribute to compromised functional use of extremities limiting their lived experiences, activities of daily living and including interactions with physical artefacts.

Interventions can clearly affect lifelong outcomes and the trajectory of development of young people with CP. Several findings in a recent review by Korzeniewski et al. (2018) of the complex aetiology of CP concluded that despite a decline in prevalence, the minimum age of reliable diagnosis is still controversial. Furthermore, no consensus exists as to the subtypes of CP which may have different aetiologies. Intervention is typically focused on treatments that prevent complications that arise from the effects of CP. Functional consequences can be progressive, e.g. musculoskeletal surgery to correct abnormalities, medical drug treatments to reduce seizures, pain related to muscular spasms, rehabilitation programmes such as physical therapy, occupational and speech therapies, see Miller (2007). Importantly, and again timely for my research, is that evidence remains sparse for intervention outcomes for motor improvement. For an update on multidisciplinary approaches to CP, see again Panteliadis (2018).

In the UK, national guidelines for assessment and management of CP can be accessed through NICE (2018). They highlight that in terms of longevity, *'there are now probably at least 3 times as many adults as children with CP this presents a considerable challenge for health and social services in the 21st century'*. This speaks to the need and challenges for early intervention and portage (home intervention for SEND pre-schoolers), in this case for young people with CP. Steenbergen and colleagues in the Netherlands have reviewed the feasibility and effectiveness of home-based interventions and proposed protocols for a systematic review of such therapies, Beckers et al. (2015). This work was followed by motor learning bimanual training protocols for children with CP, see Schnackers et al. (2018).

2.2.3 Conceptualization of DisAbility

The historic construction of disability, rehabilitation and changes in practice falls outside the main scope of this thesis. However, as transdisciplinary researchers/practitioners we should perhaps consider re-thinking not only *gesture-as-performance* but also the nature of *professional alignment* within such complex systems. For example, practitioners in the fields of medicine, allied therapies, education and performing arts can be considered domain professionals. However, their relationship to disabled people could be considered in term of *'partners rather than patients'*, see Cameron (2014a; 2014b). This is perhaps more the case in the field of participatory arts, where people typically can work as *collaborator* with their stakeholders. Read in this context, we could become more allied to the community within which we operate, see Finkelstein (1999).

I would suggest that such re-alignment supports the ethos of the work of this thesis. My biological systems approach not only brings together theoretical domains but also supports an approach where each stakeholder is valued through their interaction of joint experience, genuine participation and engagement. As practitioners, we can learn from just two examples of a young person and an adult with cerebral palsy who have achieved well-being through realising their individual, social and cultural capital. Cardinali (2015) illustrates freedom to move through dance and Clark (2012) empowerment through using their voice as a comedian. Two further examples illustrate alternative perspectives largely voiced, where corporeal expressivity is not defined by the medical lens. For Overboe, cited in Goodley (2017), they:

'reject the stereotypical disabled body defined as deficient, and refigure it as a place of becoming, reflection and production'...describing 'his spasms (normatively and medically understood as a sign of negative affliction of his Cerebral Palsy) as creative elements of his embodiment' (ibid p.89.)

Goodley goes on to argue for a critical disabilities studies approach as being the way to disentangle and warns that global perspectives need to '*recognize specific socio-historical conditions of oppression alongside wider considerations of the globalization of disablism*'. This is equally relevant when considering scientific literature from the predominately global north.

I would argue that a re-focusing on such factors offers us the opportunity to reconsider how to enrich human potential and capacity through corporeal expression. Furthermore, I would go on to argue that all our children and young people should have access to opportunities for expressive engagement, whether within education, therapy, the medical sector or the arts. Importantly, this should be irrespective of established perceptions of their capacities. Evidence from my findings illustrates how we can begin to gain a deeper understanding of the complex nature of cerebral palsy gesture as it unfolds within a dynamic system.

2.2.4 Classification and Scope of Interaction

GMFCS, MACS, ICF-CY

In order for the work of this thesis to be accessible to clinical colleagues, a summary of functional classification systems for cerebral palsy in terms of limb and hands and communications systems is provided for reference in the appendix. The neuro-atypical children with cerebral palsy who contributed to the Child Gesture Corpus can be classified as having the most limited classification of functional movements, i.e. Gross Motor Function Classification System (GMFCS) level IV-V (i.e. needing supported mobility); and in MACS (Manual Ability Classification System, see Eliasson et al. 2006) levels IV and V, for IV:

'handles a limited selection of easily managed objects in adapted situations; performs parts of an activity with effort and with limited success, requires continuous support and assistance and/or adapted equipment, for even partial achievement of the activity and for V: does not handle objects and has severely limited ability to perform even simple actions, requires total assistance,' ibid.

Furthermore, as a result of their severe dysarthric speech disorders, external augmented and alternative communication (AAC) aides had been introduced to all young people with CP involved in the study. The majority of the literature in this review revealed that only a minority of studies involve cerebral palsy children who are classified as functioning at the upper end of the GMFCS, i.e. levels IV-V and the MACS scale level IV-V.

The scope of interaction is illustrated graphically by Miller (2007) in terms of the care model for cerebral palsy children. I interpret this as a complex system where there are a large

number of *spheres of influence* that impact on the life of children with cerebral palsy. Clinical and pedagogic practice involves multi-disciplinary teams of practitioners, including physicians, physical, occupational and speech therapists, educators and in the USA cognitive academic therapists. Figure 2.2 Illustrates 19 spheres of influence represented in four colours as **Pink:** Patient and Family; **Green:** *Educational System*; **Purple:** *Clinic Team*; **Blue:** *Medical Care Team* and **Yellow:** *Community Relationships*. This ecological context is relevant for the grounding of my thesis.



Figure 2.2 Care for a cerebral palsy child interpreted as 19 Spheres of influence after Miller (2007), illustration by E. Browne.

The current biopsychosocial model World Health Organization (WHO) model for disability is the International Classification of Functioning, Disability and Health (ICF) (2001/4). An increasing number of practitioners have begun to examine Cerebral Palsy within this framework (ICF), which was modified to include older children ICF-CY in 2007. It should be noted that at the time the Child Gesture Corpus was collected the ICF-CY was not developed.

This model recommends a re-focusing on *abilities* compared with the standard *deficit* model of disability. The WHO model centres on functional activity together with *participation* and *contextual factors* that in turn influence health, including disorder or disease. It can be described as considering six broad spheres of influence described as: *Activity*-the execution of a task or action, and *Participation*-involvement in a life situation. *Body Function* refers to the physiological and psychological functions of the body system; *Body structures* are the anatomical body parts such as organs and limbs; *Environmental factors* make up the physical and social and attitudinal environments in which people live and

conduct their lives, see Figure 2.3 and the glossary for more complete descriptions. For reviews that include the concept of *activity limitations*, *habitual physical activity* and *culture*, see Granlund et al. 2012; Bøttcher 2012 and Keawutan et al (2014). Reference should also be made to the WHO policy framework Health 2020 (2013).

Support for the need for new ideas was illustrated by the reflection of leading practitioners in the field of child disability who seriously question decades of traditional practice. For example, Rosenbaum and Gorter (2012) proposed the notion of the ‘F’ words to emphasise the need to re-consider our traditional models of practice, particularly when working in the area of neuro-disability in relation to quality of life (QOL). In this case: Body structure is related to *Fitness*; Activity to *Function*; Participation to *Friendships*; Environmental Factors to *Family Factors* and Personal Factors to *Fun*.

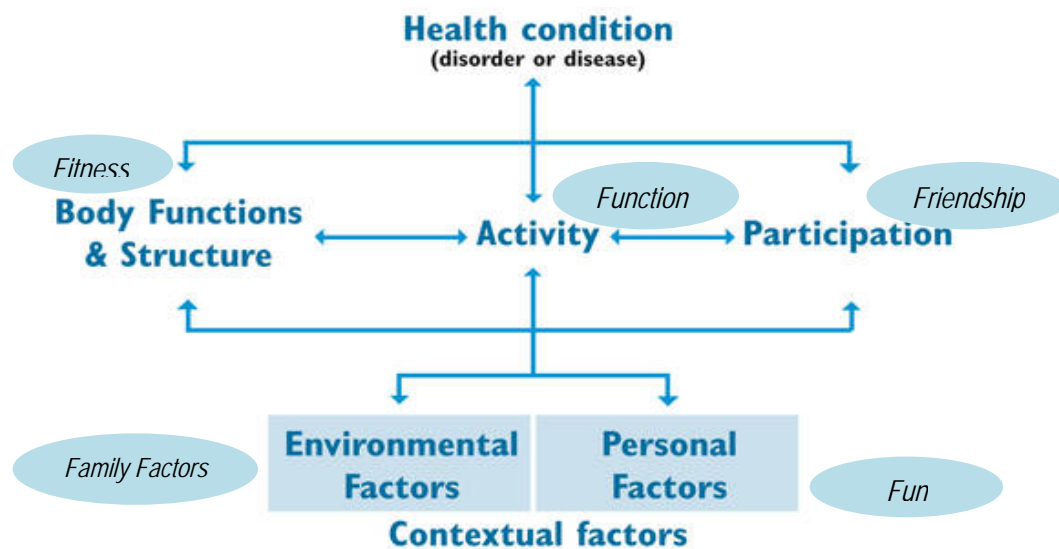


Figure 2.3 (ICF) Model. World Health Organization (WHO) (2004) and ICF-CY (2007) with five ‘F’ words modification indicated in italics in the blue ellipses [my additions] after Rosenbaum and Gorter (2012).

In my thesis, the methodology that supported the contribution of children with cerebral palsy (see chapter 3) and the C-i-A conceptual framework can be retrospectively framed to extend Rosenbaum and Gorter’s five ‘F’ words modification that they propose to the ICF model (2012). In Figure 2.3 I have incorporated this into the ICY model. In later articles Rosenbaum (2013) goes on to argue for the term ‘*developmental disability*’ to be used by professionals working in the arena of childhood disability. He describes this as a conceptual approach that both challenges the naivety of traditional practices and endorses a move away from models and practice that advocate treatment to achieve norms. He argues that: ‘*in childhood disability our efforts have traditionally been directed at trying to promote ‘normal function, and trying to discourage children from developing bad habits that are considered*

'abnormal', (ibid, p.3.). He makes the point that so called 'treatments' may be a misnomer and what we should be looking at are: *'broader goals that 'developmental rehabilitation' should really be about 'that we think about, and strive to enhance, their process of being, belonging and becoming'*, (ibid, p.4).

Furthermore, since the introduction of the ICF model practitioners have begun to re-consider how children with cerebral palsy and their families can more effectively become involved with their care providers. Imms et al. (2016) identified that transition in the ICF-CY domains limits our capacity to design interventions that could enhance participation of young people with CP. They argue for the focus to be on interaction with the environment and the people rather than the body function per se. They propose the construct of fPRC - Family of Participation-Related Constructs where participation is an entry point (process) and outcome (endpoint). Importantly, they suggest that *'further qualifiers focussing explicitly on attending and degree of involvement'* within *'an overarching environmental framework'* are needed. They also identify the need for a transactional focus that requires the use of *'analytical methods that connect ecological levels'* (ibid). An example they give is that of multi-level analysis using structural equation modelling.

This work can be contrasted with work in therapies that focus on SMART criteria based (i.e. Specific, Measurable, Achievable, Relevant and Timed) goal-setting, including in Goal Attainment Scaling (GAS). An example is given by Carroll et al (2014) for children who have cerebral palsy GMFCS level V. For an example of a study that looks at the quality and relevance from a client's perspective, see Bexelius et al. (2018). Pritchard-Wiart and Phelan (2018) provide a scoping review that specifically looks at goal-setting in paediatric rehabilitation for children with motor disabilities. They found significant gaps *'explicating theoretical basis for goals setting... and research evaluating the effects of goal quality, setting process on the achievement of meaningful outcomes'*, ibid. The issues raised by goal setting are revisited in the ensuing chapters.

Further work by Davis et al. (2017) working with parents examines how to capture participation of young people with SSMI-CP, including those with intellectual disability.

The key features of his findings have been summarized below.

- *Adequate and timely response to physical and emotional needs*
- *Building and maintain communication skills with social and community involvement*
- *Aim for best possible levels of independence*
- *Novel themes in relation to 'predictable routines'*
- *Opportunities for time in 'natural environment'*

The gaps they identify as warranting more attention were;

- *Environmental factors beyond the physical such as the social, cultural, attitudinal and institutional, should be considered*
- *Standardised assessments that incorporate psychometric measures of participation and environment were poorly reported*

Hoare et al. (2018) suggest a protocol for a prospective multi-centre and cross-sectional study of looking at cognition and bimanual performance in children between 6-12 years with CP. The authors state that the process underlying such tasks, *'have not yet been studied concurrently'*, (ibid, p12). They intend to extend measures beyond general intellectual functioning to executive functioning. They highlight that *'The relationship between EF and bimanual performance is yet to be explored in children with CP'*, (ibid, p4). For baseline executive function and attentional control, speed etc. they propose using established tools including, e.g. Behaviour Rating Inventory of Executive Function (BRIEF), citing Giola et al. (2000) and for attention control Test of Everyday Attention for Children (TEA-Ch), citing Manly et al. (1999) and for self-monitoring, inhibition task and speed of processing the NEPSY-II, citing Korkman et al. (2007) and WISC-IV citing Weschler (2003). The authors gave consideration to neuropathology, citing a systematic review for children with CP, Wejerink et al. (2013) and for cognitive monitoring and the development of an assessment protocol see Bottcher et al. (2016). The authors envisage the impact of such measures on future clinical practices to be significant.

Such research examples and prospective work, further indicates the timeliness of my research work. The psychometric potential of the tools developed in my research is discussed further in Chapter 3-6 and the theoretical framework introduced in Chapter 1 is iterated further in Chapter 7-8 and discussed in Chapter 9.

2.2.5 Activity: Capacity, Capability and Performance

The term *Activity* in the clinical literature is expanded by the qualifiers *Capacity*, *Capability* and *Performance*. However, they may be used interchangeably within clinical settings. The *Capacity* qualifier in ICF indicates the extent of activity limitation in terms of ability to execute a task or action. It focuses on an individual's *'inherent'* or *'intrinsic'* factor relating to state of health, i.e. without augmented assistance provided either by others or assistive artefacts such as communicators, mobility aids or environmental control. In the clinical setting this is often assessed in a standardized or controlled environment. In contrast, *capability* refers to the *power or ability to perform or achieve certain actions*. This notion of

activity and ability is discussed further in ensuing chapters as it has particular relevance to the proposed C-i-A conceptual framework and development of the tools.

Performance

In the ICF classification *Performance* is considered as the extent of participation restriction, i.e. difficulty in *doing*, and described by the qualifier as the ‘*actual performance of a task or action in his or her current environment*’. Since the environment includes the societal context, performance can also be understood as ‘*involvement in a life situation*’ or ‘*the lived experience*’ of the person. This notion of lived experience was introduced in chapter 1 and is discussed further in ensuing chapters. It is relevant to phenomenological underpinnings of the C-i-A framework.

As an extension to medical models and augmentative and alternative communication (AAC) practices, I use the positive paradigm of *enaction* to describe the abilities of children with cerebral palsy. This term uses notions from the performance art domain which allow for gesture to be described as *gesture-in-performance*, i.e. a child’s capacity for and capability to gesture. It is this notion of gestural enaction that provides a starting point to re-think the conventional notions of ability as capacity, capability and performance. An additional advantage of the C-i-A framework is that it has the potential to be applied to explore capacity, capability and performance across different environmental contexts and over time.

However, it should be noted that relatively little research has focused on comparing performance across different environmental settings. For an outline of these constructs in relation to motor activities of young children (at 30 months) with cerebral palsy, see Holsbeeke et al. (2009). Their results were consistent with the study of cerebral palsy children’s activity across home, school, outdoor and community settings by Tieman et al. (2004) who showed that motor performance is only partly reflected by motor capacity and capability levels.

A brief mention should be made here of a review that examined instruments used to assess capacity and perceived performance in two clinically similar populations: those with stroke and those with cerebral palsy. The authors identified a ‘dearth’ of instruments assessing actual performance. Importantly for the implications for research and practice, including the generalizability of my own work, they go on to state that:

‘For actual performance, new instruments have to be developed, with specific focus on the usability in different patient populations and the assessment of quality of use as well as amount of use. Also, consensus about the choice and use of instruments within and across populations is needed.’ Lemmens et al. (2012)

Furthermore, the importance of and the need for neuropsychological profiling and cognitive assessment more specifically, is highlighted by Stadskleiv et al. (2017) in the context of developing communicative capacity in children with CP.

Play

It is well established in the literature that the opportunities for play influence both socio-cognitive development including not only communication but also motor abilities needed to interact with the world and objects, see Kelly-Vance & Ryalls (2014). This is even more so the case for children with disability, see Pfeifer et al. (2011); Besio (2017). For young children with CP specifically, see Chiarello et al. (2018), who examine the determinants of play. For a systematic review of the reliability and validity of play-based assessments of motor and cognitive systems in young children, see O'Grady & Dusing (2015). By implication both the opportunities and the experiences of play for young children with SSMI-CP are severely limited.

The argument for constructional play is made and this lends further support to the timeliness of protocols presented in my research work. Most importantly, my protocols offer the aided communicator with SSMI-CP direct access to corporeal experiences.

The role of ludic interaction and play are discussed further in ensuing chapters. The context of everyday communication for children and young people is summarized in the section that follows.

The ludic protocols for engagement presented in Chapter 3 onwards are ecologically valid, and at the same time psychometrically sound. Importantly, they allow for corporeal interactivity to be explored at various levels. The proposed tools are being made accessible to parents, carers and professionals and would require minimal training.

Communication Aided and Non-Aided

Reichle et al (2016) describe augmentative and alternative communication (AAC) as systems that use either unaided AAC such as signs, gestures and/or vocalizations, and/or technology-supported communication that uses a range of low technology, e.g. pictures/symbol, typically paper based to high end technology such as synthetic speech-output devices (SGD) accessed directly or through switch/eye gaze activation/selection. Griffiths & Addison (2017) provide an instructional summary article that introduces access to communication technology for children with cerebral palsy in the UK. At a practical level the therapists typically need to identify appropriate body sites such as: hand/foot, mouth, eyes,

head and vocalization to establish access points for communication aides. Interestingly, such studies involved between 1 and fewer than 10 participants. The body sites can also be matched with physiological inputs, e.g. movement, hyperkinetic movement, expression or skin temperature/resistance, heart rate etc. This output is then coupled with sensor technology to facilitate functional access to screen-based output commands or to communicate affect, e.g. emotional state.

Griffiths & Addison (2017) looked at access, assessment and system selection issues for children with CP with complex presentations, within the context of the ICY (2001) and WHO priorities for assistive products (2016). They argue for a multi-disciplinary approach and practice including where,

'Access in its broadest context includes not just the physical skills of the AAC user and the technology they are using, but also the task, environment, context and the skills of the communication partners.' (ibid, p.475).

Efficacy

Earlier and more recent systematic reviews by Pennington et al. (2004/2011/2017) identified the need for further evidence to support the efficacy of current interventions in speech and language therapy for children with cerebral palsy. Myrden et al. (2014) examined trends in communicative access solutions for cerebral palsy. They highlight that:

'It is estimated that 40% of children with cerebral palsy, particularly those at Gross Motor Function Classification System level IV or V, experience some degree of difficulty with expressive communication', ibid.

Importantly, the findings of Hustad et al. (2016) supported by Pennington, argue that:

'further research is required to examine the contribution of both speech and language to intelligibility, which is currently not well understood' p.535 Pennington (2016).

The work of Simacek et al. (2018) is an example of a recent review that specifically highlights the limited evidence in the area of both unaided and aided augmentative and alternative communication for people with severe to profound multiple disabilities. Interestingly, they identify intensity, dosage and symbols type selection as important considerations when compiling AAC systems. They do this in the context of advances in technologies. They also cite the work of Johnston et al. (2012) who *'recommended an individualized comparison of aided and non-aided systems in deciding which communicative option to emphasize.'* (ibid, p.105). In their conclusions, they argue both for further research to drive the effectiveness and efficiency of AAC interventions and the need for earlier intervention. In this context, one aspect of cognition particularly important for corporeal

expressivity is the visual spatial domain. Stadskleiv et al. (2018) work looked at how visual-spatial cognition/communication can become compromised by lack of enriched language use and/or reduced access to physical interactivity. This is the case for young people operating at GMFCS levels VI-V. These authors also cite Sameroff (2010), who emphasises the need for atypical young people to be able to participate in *'dynamic and ongoing transactions between the individual and his or her environment'*, (ibid p76). Stadskleiv et al. also provide a timely summary of specialist communication hardware systems (mainly mid-tech), more recent availability of software applications for generic platforms (emerging high-tech) and access solutions.

Importantly, in the case studies presented in my thesis the co-participants' AAC devices were excluded by mutual agreement to allow opportunities for the exploration of inter-corporeal interaction. These communicator machines often mask the corporeal expressivity of their users. It should however be noted, that the difficulty of achieving intersubjectivity and corporeal attunement when using AAC devices, has only recently been highlighted in the literature, see Auer and Hörmeyer (2015).

Physical and Occupational Therapies

The past two decades have seen both developments in how to classify and conceptualize models of disAbility and their consequent influence on movement science and clinical approaches. These have included concepts from dynamic systems theory of motor learning, control and embodiment. To reiterate, researchers who recently examined the issue of impact of knowledge on practice found that for therapists, although *'a change in their clinical practice has occurred in the last year, gaps still exist and the shift has not been fully incorporated'*, see Anaby et al. 2018. Therapeutic practices still predominately focus on abilities to complete largely functional tasks (activities, i.e. personal) and participation (i.e. socially) in everyday ecological settings. These researchers argue that such clinically-based approaches still direct the majority of effort towards *'changing aspects of the child, although evidence for benefit is limited'* (ibid, p13). Importantly, they also found that: *'impairment-level approaches are not grounded in evidence and it is uncertain whether such efforts will translate into improved functional independence.'* Anaby also raises the issue of clinical realities of practice which they term the *'know-do'* gap.

I would argue that from a practitioner perspective a key question to keep in mind is: *Can interaction conditions be influenced in a way that can firstly reveal gestural capacity in children and secondly develop their capabilities?*

Several reviews have been carried out on the impact on children with cerebral palsy for clinical practice in physiotherapy. Wilson (2006) provided an early review of the efficacy of physiotherapy practice. His recommendations suggested that practice should be better informed by neuroscience findings and alternative dynamic models should be considered. Novak's study (2012) examines the evidence base to practice and asked the question: *Is more therapy better?* For an example of a systematic review that re-examines outcomes for children, adolescents and their families in terms of rehabilitation intervention, see Tatla et al. (2013). Later collaborative work by Novak et al. (2017) also advocates for both early accurate diagnosis and interventions for children with CP.

Work by Bartlett et al. (2010) in their *MOVE & PLAY* project is illustrative of multi-site and stakeholder involvement in identifying the needs and how these can be addressed in children with movement disorders (CP). This first project looked at how engagement and participation could be more active. Their next project, *On Track* (2016), focuses on primary and secondary impairment impacts on factors including: impact on *health conditions, self-care and leisure*. In later work Bartlett et al. (2018) look at producing knowledge of determinants of to inform long term individualized profiles of care. Evidence can be also found in systematic reviews of the efficacy of non-drug interventions in the context of multidisciplinary approaches to CP, Panteliadis (2018). It should be noted that the majority of clinical interventions take place on an individual basis. The majority of interventions still focus on physical and communicative activities that focus on a conceptual model of '*restoration of function*'. A more detailed discussion of these issues falls outside the scope of my thesis, but further analysis can be found signposted in the references and bibliography section of my thesis.

The efficacy of the physical and occupational therapies is identified as needing a more rigorous evidence base. Two key points are summarized in Box 2.1 in the context of the aims of my thesis.

- ❖ *There is a need to re-examine the nature of the activities and the levels of motivation*
- ❖ *The levels of participation both with social others and artefacts are severely restricted and compromised for children with motor disorders, particularly children with cerebral palsy.*

Box 2.1 Identified improvements to efficacy for physical and occupational therapies

2.2.6 Applied Participatory Performance Art

Trends towards situate, embodied and enacted practices, particularly in alternative therapies that focus on performing and participatory arts, are being seen in the applied participatory performing arts sector. Such transdisciplinary approaches are being considered within the disciplines of embodied performance and are being applied in research that brings together performance art and pedagogy.

Participatory Theatre

Scott (2018) and Scott et al. (2015) are examples of work that focuses on disabled embodiment in particular, although not cerebral palsy. Scott's work focuses on '*performance as applied learning, disabled embodiment and identity as performance*'. For examples of work on '*performance, autobiography, applied and socially engaged theatre*' including work with children with autism, see Shaughnessy (2016; 2017). Shaughnessy's research examines both the theory and practice of '*cognition, kinaesthetic and performance*'. She works on evaluation of the role of creative practice as embodied methodology and pedagogy. Of particular interest is her work that focuses on the role of imagination in drama intervention, see Beadle-Brown et al. (2017).

Dance

A further example in the area of applied performance is the work of Teixeira-Machado and Coutinho (2018) who promote dance as: '*Health education through arts that generates an interface with culture*', which in turn can '*shape their health and their being in the society in which they live*'. They also cite work in the arena of intracorporeal dance by Purser (2017). Similarly, Maconochie (2018) makes the case for practices that focus on the embodied participation of young disabled children.

Music

The importance of participatory design was highlighted in earlier collaborative work that created a non-encumbered virtual soundscape for young people with cerebral palsy to corporeally access music composition. We used the Rokeby system and Max mapping software. Interactive space incorporate physical objects and theatre for further details, see Panayi & Roy (1994).

More recently, in the music arena, the work of McCloskey et al (2015) is an example that illustrates how participatory design with young people with quadriplegic CP can give increased independence and access to real-time digital music making. They focused on mapping constricted gesture movements that had repeatable dynamic features. Such features

were then utilised using Arduino prototyping platform and Max for re-mapping and sound synthesis.

In the participatory music sector, the work of Vogiatzoglou et al. (2011) with their *Sounds of Intent (SOI)* project and *Nordoff-Robbins Scales*, Bell et al. (2014) exemplify how music can be used to enhance creative experiences for people who typically have limited access to music. Nordoff-Robbins practitioners use *The Music Therapy Communication and Social Interaction Scale (MTCISI)* to document creative process. In the case of the SOI framework, an online resource allows for sharing of videos and interactive software supports the documentation of assessment/skills progression and visual representation through a cyclic matrix.

Social Circus

An exciting and visionary pilot study recently examined the potential of increasing social participation of young people with physical disabilities through the practice of *social circus* (Cirque du Soleil), Loisel et al. (2018). The idea of 'Art for Social Change' in this case uses *social circus* to build both physical and 'soft skills'. It is the first time in 20 years that this social circus program has been documented. The conceptual model underpinning their work was qualitative, phenomenological and one that supports the development of creative processes. The cultural context of the work is the Convention on the Rights of Persons with Disabilities (2007). The authors cite associated work including small studies and reviews where available in the expressive and creative arts including therapeutic practices, see Goyal et al (2008) – expressive arts; Perruzza et al. (2010) - creative arts; Pratt (2004) for art, dance and music therapy and Agnihotri et al. (2012; 2015) for theatre based work. This work carries a particular resonance with the corporeal focus and conceptual framework presented in my work.

2.2.7 Technology Enhanced Capture, Interactions and Interventions

The Technology strand of the Biological System Theory review focuses on the need for theoretical models that underpin our understanding of the social nature interaction in order to better inform technological developments. In this section I give a brief overview of selected systematic reviews from the domains of applied engineering and rehabilitation, health and the performance arts to inform the aims of my thesis.

Virtual reality sensor technology and immersive environments have been used in entertainment for some time and latterly, i.e. for the last 10-15 years, in the rehabilitation

arena. However, there have been a limited number of studies examining the use of such environments for children with cerebral palsy. It should be mentioned that the majority of studies often do not involve children classified beyond level III of the GMFCS. With emerging online engagement such technologies offer researchers and practitioners further opportunities to explore child interaction, including those with virtual/avatar characters and scenarios, see Sundlund et al. (2009), Laufer et al. (2011) and López et al. (2017).

In the case of neuro-atypical populations such as children with CP, the majority of the literature focuses on technology designed to measure functional movement or attempts at computer recognition of movement. A search of literature that examined gesture in cerebral palsy revealed relatively few studies. However, advances in computing power, algorithm software and the development of miniaturized hardware peripherals have begun to highlight alternative possibilities. Amongst the alternatives are non-invasive sensors, in particular mobile-wearable technologies, e.g. accelerometers, biometric, piezoelectric and motion-tracking technologies that are being used to capture human action and body state such as arousal and affect. The two recent pieces of research that follow are illustrative of trends towards body-centred computing, Benford et al. (2017) creative computing. Salazar Sutil (2018). Salazar Sutil (2018) begins to advocate for transdisciplinary frameworks not yet defined, to support emerging practices that go beyond just dance which he terms - *kinetopoiesis*. With other authors they propose looking at whole body interaction (Gilles et al 2014) and the idea of *corporeal computing*. Such approaches would contribute to more open-endedness computing strategies for both the capture and understanding of corporeal movement and thinking processes.

I argue that such non-invasive sensor, vision-based, mobile and/or wearable technologies can be combined in a data sensor fusion paradigm. Supported by more sophisticated software computing approaches, these approaches have the potential to support the development of future intimate technologies. Intimate technologies are those that are either chosen by or are essential to the involvement of the people in social and/or creative interactions. These interactions can unfold, be brought forth and evolve in the veridical world or in a hybrid context.

Gaming and Gamification

The timeliness of my work, particularly the ludic game protocols, is seen in its potential to be combined with technologies that have the capacity to capture enactive actions and interactions. This is exemplified in part by work in paediatric rehabilitation, pedagogic

learning, edutainment and leisure gaming, alternative therapies and performance art. More recently, commercially available systems have become available for home use. These include system interfaces that can capture more active movement of the user, e.g. arm, wrist, head acceleration and simple body gestures - for Nintendo's Wii and Microsoft's Kinect, see Microsoft.com. For a review of rehabilitation applications with the use of markerless motion capture, including people with CP, see Knippenberg (2017). Chen et al. (2012) reviewed state of the art technology used to assess physical activity with a focus on sensors and their properties. Transducers convert one type of energy, e.g. motion, to a physical attribute such as posture. The signal is then processed and properties examined. Movement sensors can be used to measure angles, postures and dynamic movement features. For a systematic review and meta-analysis in this field, see Chen et al. (2018). Work by Bonney et al. (2018) found gains in motor function across several aspects including motor development and upper extremity function, using applications of VR or Augmented Reality (AR) and Active Video gaming (AVG). Moulton & Visintini (2018) produced a report outlining practices using Virtual or Augmented Reality (AG) for paediatric rehabilitation and clinical effectiveness.

Eye gaze

Whereas eye gaze driven AAC systems are more commonplace, the use of eye gaze trackers for CP research is limited. Although outside the immediate scope of my thesis, mention should be made of infant development studies that use eye-tracking technologies to explore what may be salient to mother-infant and object interaction. For example, Corbetta et al. (2012) point out both the need for ecological validity and the need to understand connectivity of neural subsystems:

'Very few attempts have been developed to assess infant eye-tracking in the context of real, three dimensional (3D) objects or scenes, and even less efforts have been made to assess how infants' looking patterns relate to the selection and decision making processes involved in the planning and execution of their actions', ibid.

Such technologies may be suitable for some neuro-atypically developing children such as those with diagnosis of autism. However, they may not be suitable for use with children with severe cerebral palsy who have restricted and /or erratic head/eye control.

Social Robotics

Extending the idea of the 'other' proposed in the C-i-A framework, either as co-performers, virtual therapists or 'the social other', consideration is also given to research where the social is robotic. Such '*social robots*' are beginning to be used for clinical intervention. Chen et al. (2017) worked with cerebral palsy children to examine their real-

time reaching kinematics using Super Pop VR™ system. They found that children with and without CP could follow the robot's feedback for changing their kinematics reaching when playing VR games. For these young people gains could be made in:

'motor function, balance, motor development, upper extremity function, muscle strength, gait and endurance walking, hand eye co-ordination and visual speed'.

Despite limitations of *'heterogeneity and small sample sizes'*, and the use of *'various intervention protocols'*, their conclusion found that *'VR seems to be an effective intervention for improving motor function in children with CP,'* *ibid.* A review of the potential of gamifications to be incorporated with conventional intervention has also been discussed by Hsien-sheng et al. (2018).

Wearables/Tangibles

Early work by Steins et al. (2014) involved a systematic review that focused on wearable accelerometry-based technology (ABT) used for assessing functional activities in neurological populations in community settings. Their conclusions identified that although researchers could use ABT to:

'distinguish healthy from non-healthy subjects' and to 'classify functional activities and symptom severity' with high accuracy, there was little qualitative exploration of motor performance, (ibid, p.12)

They argue that the focus should perhaps be better placed both in improving well-being with *'greater nuance'* and incorporating a *'multi-disciplinary'* approach. Lugo-Gonzalez et al. (2017) through the use of exo-skeletons and Wang et al. (2017) provide a systematic review of interactive wearables for rehabilitation. In the tangible arena several authors are developing sensor embedded including malleable interfaces for engaging children with disabilities.

Combining Platforms

The technologies described in this section of the review can be coupled within a data fusion approach involving for example wireless wearable, textile and object embedded, ambient environmental sensors and/or physiological body-state sensor. These sensors have the potential not only to provide parametric data such as type, intensity, duration and quality of intentional action, but also insights as to the affect and context of human interaction.

A narrative review by Teo et al. (2016) looked at the potential of data from combined technology platforms. They looked at: VR (e.g. clinical application of stimulus presentation, interactivity, control and types of VR) together with Neuromodulation (e.g. tDCS and rTMS)

and Neuroimaging (e.g. fMRI and EEG) for neurorehabilitation. They concluded that what was needed were: *'large, longitudinal controlled trials to determine the true potential of VR therapies in various clinical populations'*. The NICE guidelines also advise caution against reliance on MRI alone for predicting prognosis of CP. It should be noted that the challenge of noisy or occluded data with such technologies still proves to be a significant issue.

Participatory Design

As with any technology development good design practice should involve the stakeholders. The importance of participatory design was highlighted in earlier collaborative work within a *'Design for All'* philosophy. The first research project involved the use of 3D motion-tracking technologies used to capture the gesture repertoire of the children who contributed to the Child Gesture Corpus. The outcome of this research was to establish proof of concept for computer recognition of dynamic arms gesture, see Roy et al. (1993) and Panayi and Roy (2005). An innovative art based project, *BodyTek: The Digital Body*, Panayi and Roy (1995) involved the use of the Rokeby wireless motion tracking DSP hardware and Max movement mapping software to encourage physical and tangible engagement of neuro-atypical young people with a non-encumbered virtual sound-scape and physical theatre scenarios, see Panayi & Roy (1994/5). The *Today's Stories* project explored concepts of autonomy and the collection of everyday narrative using wearable technologies (camera and presence infra-red). This project was an early example of how such technologies can be used in ecologically valid and pedagogic settings; see Panayi et al. (2000). All three of these previous studies highlight the importance of engagement, interaction context and limitation of technologies to capture the 'nuances' of social interaction. These social interactions clearly involve high levels of physicality and tangibility; see Roy et al. (2000).

More broadly, as an example of work with parents of children with CP as stakeholders, Davis et al. (2017) suggested that:

'it might be possible with creative use of media and technology along with skilled delivery of tailored approaches to communicate with each child. The ultimate goal would be to capture their reactions to experiences and situations' p.859 *ibid.*

Such work lends support to practices that are using interactive software to document the participation profiles of children and young people with physical/cognitive challenges. This is discussed further in the section on allied participatory arts.

The technologies and approaches critically reviewed are not discussed further detail in this thesis. Further information can be found in the reference bibliography.

Democratization of Technology Access

On a cautionary note, as already mentioned, some types of VR, neuromodulation and neuroimaging, some software and motion capture technology are inaccessible to children with SSMI-CP. However, with the accessibility of low cost motion capture systems such as Kinect, together with software developer tools, there is potential to reconsider the use of gamification as a platform for the capture and analysis of human movement; for an example see Taylor et al. (2015). Such systems, coupled with IMU (Inertial Measurement Units) and EMG (Electromyography sensors), could add additional quantitative evaluation of motor function. This type of data sensor fusion could contribute to clinical outcomes of interventions and inform future therapeutic intervention protocols; for examples see Roy & Panayi (1993); Li et al. (2017) and Esfahlani et al. (2018).

This aspect of the literature review illustrates not only the trend, but also the potential for online clinical interventions and therapeutic gamification with and without artefacts such as robots. Such work could provide alternatives and/or extension to extend face-to-face therapy sessions. The work discussed here is illustrative of how both the intentionality premise and artefact concept within the C-i-A model could also encompass advances in a wide range of technologies. It is clearly within this technology arena that researchers have the opportunity to reconsider the tools that they may be able use to not only capture but also understand intentionality.

Integrated with nuanced interaction protocols and systems, they could be developed to support the physical participation of children with severe motor impairment. However, I would argue that to achieve greater nuance we still need human co-participation and observation.

2.2.8 Implications for Intervention & Psychometric Assessment

Such transdisciplinary approaches are illustrative of work that brings together both theoretical grounding and embodied practitioner methodologies. These include ethnographic methodologies of theatre, dance, music and film. Such examples illustrate how the participatory art can cross the clinical boundaries. Aspects of C-i-A theoretical framework, the interaction protocols together with the annotation and analysis tools could provide alternatives and/or provide adjuncts to traditional interventions. This would make them more accessible to young people with higher levels of physical involvement, i.e. level IV-V. These could include for example the allied and participatory arts intervention, VR and exercise

interventions therapies discussed earlier in my literature review. The implications and outcomes of my thesis are discussed in the ensuing chapters including Chapter 9.

The implications and potential for development of my body-base action annotation system (G-ABAS) are introduced in Chapter 4, together with the Interpretative Phenomenological Analysis (IPA) that has been adapted and applied to intentional gestural action. In my thesis, these tools are used for both inventory and for the analysis movement components. Subsequent interpretative analyses reveal the *sense-making* capacities that children can express through their gesture performance. Such tools have the potential to enhance existing classification systems. The implications of my research review discussions illustrate how the C-i-A framework and associated tools are timely and could also contribute to both psychometric assessment and provide protocols for the development of corporeal expressivity.

Such literature and findings once again illustrate my new contributions to knowledge in the area of corporeal expressivity of people with Cerebral Palsy. The enactive approach has three additional advantages highlighted in Box 2.2 below.

- ❖ *places the action-ready body centre stage (Body Function and Structure: Fitness)*
- ❖ *offers ludic gestural interaction protocols (Activity: fun/function) that involve high levels of motivational engagement and*
- ❖ *participation with social others and artefacts (Participation: Friendships; Environmental Factors and Personal Factors)*

Box 2.2 Advantages of the enactive approach to interactive therapies

2.2.9 Summary

In this first section of my review I evaluate models that attempt critical reconsideration of medical deficit-driven models that have dominated and impacted on the lives of children with cerebral palsy. In Figures 2.2 -2.3, I presented a schematic model the ICF relevant to cerebral palsy. I identify both the research gap for holistic conceptual frameworks and the limitations of existing clinical, therapeutic practices, particularly in terms of the lack of evidence of efficacy; see also Boxes 2.1 and 2.2.

I concur with lead practitioners on the need to re-consider non-holistic, conventional, representational models of existing medical practice in the care of children with cerebral palsy. I reviewed research that addresses the challenges of engagement; activity and quality of participation of young people with SSMI-CP. Points have been summarized in Box 2.3.

- ❖ *methodological paradigms that do not rely on deficit explanations of models of activity and*
- ❖ *frameworks that have the capacity for inclusive explanations without resorting to deficit models*

Box 2.3 Further research needed in interaction methodologies in clinical practice

I consider the potential of recent advances in motion, body state and ambient tracking technologies and the concept of data sensor fusion, within the context of the potential for using advanced motion capture and tracking technologies that provided qualitative data.

I argue that although such technologies offer significant and potentially valuable parametric data, there is need for further development. However, there still remains the need for human co-participation in order to develop deeper understanding of the complex nature of social interaction.

Thus, this part of the review validates and supports the need for better informed theoretical frameworks for understanding neuro-atypical gestural interaction. The C-i-A framework is consistent with recent calls to re-examine the theoretical underpinning of clinical practice, the efficacy of existing practice and the need to re-focus on developmental approaches to care that support ability, rather than a drive to ‘normativity’(Aims1 and 2).

In addition, the C-i-A framework and associated tools have a value in the development of future clinical interventions and psychometric assessment practice, specifically in movement inventories (Aim 2) and the development of intimate technologies (Aim 3).

2.3 Models of Action Control

This second part of the review provides a selected synthesis of neuroscience literature that examines conventional models of action control within the context of the neurology of CP and neuroscience technologies. Motor control is then examined in terms of cognition, imagery, modality and intention as an aspect of our interaction in space. I revisit the language vs gesture debate and place it within the context of dynamic systems and alternative perspectives such as the enaction paradigm. I then propose a shift from a ‘Language Ready Brain’ to an ‘Action Ready Body’

2.3.1 Motor Control Neurology of Cerebral Palsy

In this section I review traditional models of neurology and make arguments for re-thinking our conceptual frameworks for gesture and holistic practice that focus on placing the ‘Action-Ready-Body’ centre stage.

Traditional models of *neurology* focus on understanding mechanisms that underlie motor control in terms of the perception-cognition-action-cycle (PCA) - see schematic (left Figure 2.4). Typically, cognition is placed at the centre but is largely considered to be brain-bound. These models are often derived from animal and adult human models. They clearly do not consider the child as a developmental system. However, such models continue to influence clinical practice and care of children in three main areas: *orthopaedics*, *habilitation* and *pedagogy*. It should be noted that since the medical condition of children with cerebral palsy is life-long and not a remediation from illness or injury, the preferred term *habilitation* is used in place of rehabilitation in my thesis.

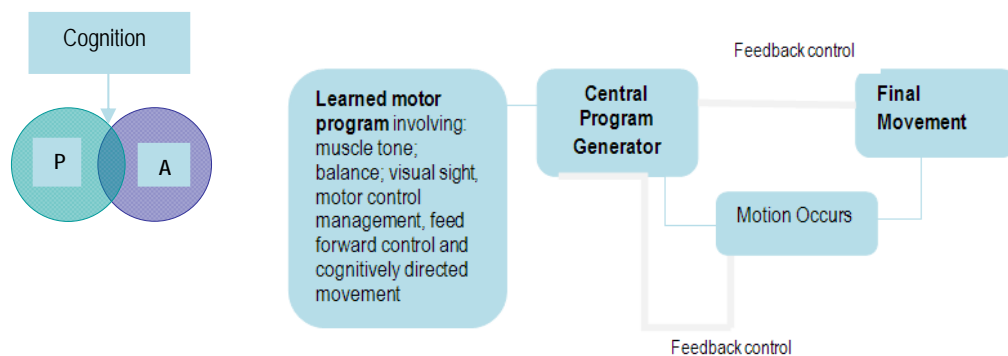


Figure 2.4 Two schematics (left) illustrate conventional PCA relationship and on the (right) the schematic illustrates elements involved in the motor control involving the cerebral cortex, thalamus/pons tracks, basal ganglia and cerebellum (together with substructure) in relation to brain stem/spinal cord.

I began by examining Miller’s example of conventional motor control model for gait that can equally be applied to intentional action generally, (right) Figure 2.4. It is illustrative of conventional representational models. I do however concur with Miller when he states that the motor control is a complex process that is ‘*poorly understood*’. The left hand column indicates bodily factors and physiology that affect a postulated ‘central program generator’ (CPG) that affects motion and final movement outcome. These are in turn influenced by ‘*some combination of feed-forward control, in which the brain uses sensory feedback and prior learning to control movement, with a closed-loop feedback system,*’ Miller (2007, p.46). This model is typically considered within a *maturation theory of control*. Miller has reviewed models from the later 1980s; Edelman (1989) proposed his Neuronal Group Selection Theory (NGST) and later Hadders-Algra (2000, 2005 and 2010) work in the context of neuro-disability and motor control. He also indicated that alternative models may need to be considered, specifically mentioning dynamic systems models. I shall return to the work of Hadders-Algra in the ensuing chapters.

Basal Ganglia and Cerebellum

Figure 2.5 illustrates the location of the *basal ganglia* and *cerebellum*, their connectivity to the cortex, thalamus and pons in relation to brain stem and spinal cord. Information is sent to both the basal ganglia and cerebellar structures from the motor cortex. Information returns via the thalamus. The two systems that make direct contact with the spinal motor neurons are the brain stem system and the cortical system; all other systems are modulatory. The *output* of the *cerebellum* is *excitatory (+)*, while the *basal ganglia* are *inhibitory (-)*. The *balance* between these two systems *allows for smooth, coordinated movement*, and a *disturbance* in either system will show up as *movement disorders*. Both the basal ganglia and cerebellum are critical for motor control integration and control.

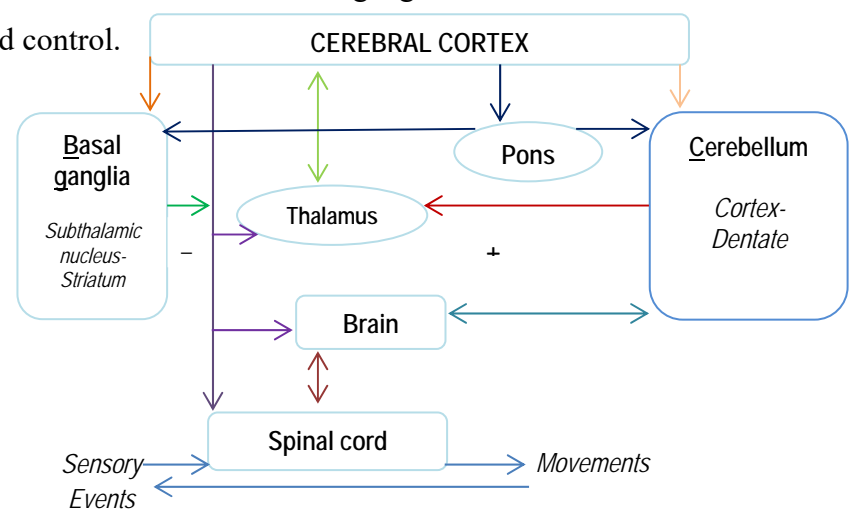


Figure 2.5 Is a simplified illustration of the neurology of Cerebral Palsy showing interconnectivity between cerebral cortex, basal ganglia and cerebellum, thalamus, pons, brain stem and spinal cord.

2.3.2 Neuroscience: Imaging Technologies and Their Limitations

In the last two decades advances in technology-based tools used to explore underlying mechanisms of neurology have influenced the development of existing conventional theoretical models, empirical research and practice. In the research arena these technologies involve predominantly non-invasive neuroimaging technologies such as functional magnetic resonance imaging (fMRI). fMRI registers blood flows to functioning areas of the brain, which in turn are used as neural-correlates for activity. Together with less restrictive and targeted technologies, e.g. Transcranial magnetic stimulation (TMS), they are offering new insights for cognitive neuroscience. However, for children with cerebral palsy, Miller (2007) sounds a cautionary note in terms of the interpretation of imaging data in relation to diagnosis and prognosis. Although it is stated that generally speaking the:

'more severe structural changes mean more severe motor and cognitive neurological disability'... 'other individuals may have equal cognitive and motor severity with near normal MRI'... 'or individuals with severe structural changes on the MRI' ..and. 'cognitively normal....' have... 'triplec patterned CP but ambulates'. (Miller, 2007 p.48)

Miller goes on to caution physicians *'not to develop prejudices concerning an individual child's function based on imaging studies'* (ibid, p.48). However, a recent study by Himmelmann et al. (2016) developed and evaluated a MRI classification system (MRICS) for children with cerebral palsy for use with CP registers. The manual provides descriptions for five main areas: *maldevelopments, predominant white matter injury, predominant grey matter injury, miscellaneous, and normal findings*. The interpretations of the Surveillance of Cerebral Palsy in Europe (SCPE) propose the *'MRICS as a reliable tool'*. Sgandurra et al (2018) had promising results with an fMRI study that examines both action observation networks and sensory motor systems in children with CP and conclude that there is potential for use to quantify to therapies.

In this context I would endorse Miller's caution that such neuro-science research paradigm and technologies still have limitations. Furthermore, I would argue that the nature of existing methodologies that underlie the technologies makes them largely unsuitable to investigate the following profiles and interaction, (see Box 2.4).

- ❖ *Rapid 3D movement, typical of cerebral palsy profiles and*
- ❖ *Dynamic, non-linear ecologically situated human action or social interaction.*

Box 2.4

Existing methodological limitations for studying the movement capacities of cerebral palsy children

My conclusions are timely in the context of a recent review by Gosling (2017) that looks at advances in neuroimaging and links to function, QOL and participation and efficacy of intervention. She goes on to discuss how such data could inform the understanding of CP in terms of paediatric neuropsychological rehabilitation. However, Gosling highlights the need:

to 'examine the efficacy in CP of using such data, arguing for neuropsychological input, as a holistic, interdisciplinary understanding of each child's unique profile is needed to plan realistic, goal-orientated rehabilitation' (ibid).

2.3.3 Models Control and Cognition

In this part of the review I re-examined traditional models of motor control and cognition. Historically, the neurology of perception and action has been linked with the assessment of the motor process; see Sperry (1952), Prinz (1984). The majority of action control models reflect the conventional fragmented and reductionist approach to the study of human action. The discovery in the mid-1990s of patterns of neural firing that were correlated to either overt or covert imitative behaviour termed the *Mirror System Hypothesis (MSH)* has heavily influenced empirical paradigms. However, as with neuro-imaging derived theories of interaction such as the Mirror System Hypothesis, their limitations need to be acknowledged.

The significance of social interaction and the more recent concept of the *social brain* are illustrative of conceptual frameworks that still confine cognition and action to within the skull. Furthermore, the theoretical underpinnings of current gesture research are typically still limited to the concept of gesture being in *service to language*. I contrast these models with more ecologically valid dynamic models of motor control. Understanding the cognitive and physical mechanisms that underlie the development of our abilities to interact is fundamental to furthering understanding of our survival as social human beings.

2.3.4 Motor Imagery and Modality

Mental Imagery

Before moving onto contemporary literature, mention should be made of earlier work as it still influences some of our theoretical and empirical thinking. Early work by Washburn (1916) on movement and mental imagery put the case for a *motor theory of imagery*. However, this model has been superseded in contemporary research. The seminal work of Paivio et al. (1965; 1971) focused on *abstractness* and *imagery* in associated learning. They proposed indexes of both these features which I shall discuss in ensuing chapters. However, some research in the 1990s did focus on examining the significance of imagery (Richardson,

1999). Various researchers have proposed that motor and visual imagery are two or more complementary, neural dissociated mental processes. For details on neural dissociation of imagery, see Kosslyn (1994b).

Ayres' work with children with apraxia provides insightful definitions and categories for considering the motor abilities of neuro-atypical children who co-participated in her studies. Specifically, her definition of *praxis* can be applied to gesture:

'the generation of volitional movement patterns for the performance of a particular action, especially the ability to select, plan, organize, and initiate the motor pattern which is the foundation of praxis,' (my bold italics) Ayres (1985).

Ayres discusses praxis in terms of spatial-temporal coordination, motor sequencing and transitions (after Netsell, 1981). Although applied to *segment duration, timing, conditioning and adaptation in language*, in my thesis they are considered and applied to the investigation of dynamic gesture. As with the findings of other researchers, the neuro-atypical participants in this study also showed disruption in volition movement, see Dewey et al. (1988). The nature of this disrupted volitional movement is widespread across the *sensory motor system*; Crary (1984), cited by Crary and Anderson (1990) who provide a comprehensive list.

Supramodality

Within my conceptual framework of C-i-A I interpret this as illustrative of the *supramodal* impact of such disruption. These types of disruption show the variability of impact of movement disorders in children with CP, although not all are present in each child. CP is considered to be heterogeneous across individuals and variability in profiles may include one or several of the following features:

kinaesthetic acuity, visual perception, static balance, postural control, slow movement preparation, reduced strength, enhanced co-activation, slow feedback processing, spatial coordination, motor coordination, learning of complex movements.

For an examination of end-point accuracy and the role of context on grip selection in hemiparetic cerebral palsy, see Steenbergen et al. (2004). More recent work by Lust et al. (2017) examined motor planning using a longitudinal design paradigm. They found that children with CP showed poor end-state planning for critical angles and that these issues did not resolve with development over time. These authors go on to suggest that: *'children with CP may be amendable to improvement by training, suggesting sufficient plasticity in the system for training to be effective* (ibid, p.6).

In an early review of clinical and diagnostic criteria for Developmental Coordination Disorder (DCD) see Geuze et al. (2001; 2005) who focused on three further aspects, namely:

spatial and temporal variability, attentional control and visual-spatial short term or working memory. Despite difficulties in sensory-motor processing, the neuro-atypical co-participants of my studies produce a significant range of intentional gestural actions. I will return to this in the discussion of children with CP playing gesture games, including attempts at reaching and grip selection strategies. These cited examples of research supported my rationale to reconsider conventional models of motor control and cognition. It should be noted that such disruption of movement patterns provided significant challenges to the computer recognition of neuro-atypical gestures as previously mentioned. Exemplars of more complex enactions from neuro-atypical children with SSMI-CP formed one of the foci in the empirical gesture study presented in my thesis.

2.3.5 Motor Imagery and Intention

Jeannerod (1994; 2001; and 2006) proposed both neural-correlates of *motor intention and imagery* and a unifying mechanism for motor cognition. Jackson et al. (2003) and Jackson and Decety (2004) also examine the potential for motor cognition. Their definition of motor cognition equated *mental practice* (imagery) and *sequence learning* as a mechanism to influence action. Arbib et al. (1981) proposed concepts of perceptual structures involved in distributed motor control.

Compared to mainstream literature of neuro-typical mother-child interaction, very few studies have focused on neuro-atypical children's imitative or non-verbal register capacity for cerebral palsy children; see van Balkom et al. (2010). Harvey et al. (2008) provides a systematic review that examines *imitation* in children with CP; once again the paradigm is one of '*limitation*'. In contrast, Zukow-Goldring and Arbib (2007) proposed a description of *dynamic synchrony* in imitation interaction between infants and their caregivers. Later work by Zukow-Goldring and de Villiers Rader (2013) suggests that '*infants detected referent-word relations best when speakers used a 'show gesture'*'. They propose a SEED framework of early language that is situated and culturally embodied and where children's language emerges through care-giver-infant interactions. They also argue that the process is a dynamically-coupled perceiving-action loop, although their explanation still remains brain-language based and reliant on the essential role of mirror neurons. However, the idea of *dynamic synchrony* at a systems level is an aspect of gestural interaction that I will discuss further in ensuing chapters. For an example of work that has influenced both the re-examination and feasibility of motor imagery training for children, including those with CP,

see Adams et al. (2017) and Alonso-Valerdi et al. (2018), who have developed Brain Computer Interface (BCI) protocols based on motor imagery.

2.3.6 Social Imagery, Interaction and Space

In this section I summarise research that I term the *social imagery* model of interaction. Once again, early work attempted to identify the importance of two features, ‘*depictive*’ and ‘*spatial imagery*’, in relation to how we orientate our self in space and how we may represent affect. Tomasello (1993 and 1996) worked on cultural learning and identified the importance of depictive imagery, linking this later to the origins of human communication, Tomasello (2008). More specifically, Tversky (2001) argues for ‘*multiple systems for spatial imagery*’. Others re-examine aspects of cognitive functions, see Paivio’s (1986) work on the imageability of words and the dual-coding hypothesis in relation to *motor imagery and imaginary tasks*. This work was previously influenced by the Baddeley and Hitch model of memory (1974).

In contrast, studies of spatial representation often use models of egocentric (*person perspective, self and other*) and allocentric (*point of view independent and relationships*), see Galati et al. (2000); Tversky (2001) and earlier work by Gallese et al. (1996), and O’Keffe and Nadel (1978).

Levinson (2008) argues that space plays a significant role in cognition and language, although Newcombe et al. (1999) and Newcombe et al. (2010) argue for both capacity in infants to ‘code’ for location in space and for a non-modular view of spatial processing. Ortigue et al. (2009) use EEG/fMRI methodologies to examine the spatio-temporal dynamic of intention. Their work builds on earlier studies that attempt to examine action representation of the self and others within social interactions (Decety and Sommerville, 2003; Decety and Grezes, 2006; Decety and Stevens, 2009). Such methodologies are also being used to investigate neurodevelopmental changes that underlie pain (Decety et al. 2008) and empathy, see Decety and Michalska (2010).

However, in the context of the corporeal framework of this thesis, such work is typically limited to the discrimination of visual hand shape and associated functional actions, e.g. reaching and grasping. The neuro-atypical children whose gestures are presented in the empirical study have significant difficulty and lack skills in such functional actions.

Two specific findings extracted from such studies are re-interpreted and considered within the non-representational Cognition-in-Action framework; see Box 2.5 below.

- ❖ *Inference for reasoning for egocentric representation based on relational information with regard to the elements within an environment, after Tversky (2001).*
- ❖ *Differential strategies involved in tasks of motor imagery, one of simulation of action based on kinaesthetic memory of executed movement and one of visualization of movements from visual kinematic imagery, without actual movement, after Sirigu et al. (1996).*

Box 2.5 Inference for reasoning and strategies underlying motor imagery

More specifically, the salience of relational interaction and the notion of kinaesthetic memory together with visual kinematic imagery are considered in the analysis of child gesture, see empirical study chapter 4 onwards.

For a review of approaches that examines the role of *words as tools*, and their underlying neurology, see Caligiore et al. (2010). The concept of *words as tools* is derivative of the work of Wittgenstein's philosophical concept that we play games with words (Wittgenstein, 1953). This inherent flexibility of words does, however, make language a powerful tool for exploring gesture. These authors proposed that:

'aside from the cortical action understanding network, sub-cortical processes pivoting on cerebellar and basal ganglia cortical loops could crucially support both the expression and the acquisition of action understanding abilities' ibid, 2013.

To reiterate, the major limitations of such studies are that the empirical work and modelling for humans is predicated on linguistic models that focus on the role of words and action within a *language framework*. Although the work of Caligiore et al. (2017) is indicative of a gradual shift towards system level think, this is discussed in sections that follow.

2.3.7 Language Ready Brain or Action Ready Body Mirror-Neurons, Imitation and Imagery

Arbib and Rizzolatti (1997) and Arbib (2002; 2005) make convincing arguments on the evolutionary implications of imitation for human language development. Rothi et al. (1997) found that about 30% of the activation in the motor cortex is related to motor imagery effects during inferred mental simulation (pre-performance or rehearsal). These findings were supplemented by Buccino et al. (2001) and Arbib (2004) with work on *action observation*.

The influential Mirror System Hypothesis (MSH) proposed by Arbib and Rizzolatti was based on earlier work by Decety et al. (1996; 2006); Rizzolatti et al. (1996) and Gallese (2003) and stems from work on primates. It advocates for a *'language ready brain'* with neurological correlates for language capacity located in Broca's area. They argue for a mirror neuron system that underlies a capacity for both generating and recognizing sets of actions.

Specifically, they state that mirror neurons do not recognize *gesture per se*, but '*action = movement + goal*'. These mirror neurons are found to fire when the action of others is being observed. They are also correlated to neuron firing during explicit action performance see Arbib (2002; 2004; 2004a; 2004b). Grafton et al. (1996) had earlier suggested neural-correlates for grasp representation. Work by Oztop, Arbib and Oztop (2002); and Oztop et al. (2004) developed this further and proposes a model for infant grasp that implicates mirror neurons - Infant Learning Grasp Model (ILGM). The MSH and the ILGM offer brain based neuro-correlate explanations for imitative behaviour.

Molenberghs et al. (2009) provided a brief review and meta-analysis for the involvement of mirror neurons in imitation. Corballis (2010) offers arguments for both the prospects and problems that the neurology of language that carries, they discuss this in relation to the implications for this area of research. For a review of the implication of the evolution of mirror neurons in terms of their prospective, extended and highly distributed nature, specifically their occurrence in subcortical structures related to visceromotor reactions, see Bonini and Ferrari (2011).

Coudé & Ferrari (2018) discuss how it is now generally accepted that:

'the motor system is not purely dedicated to the control of behavior, but also has cognitive functions. Mirror neurons have provided a new perspective on how sensory information regarding others' actions and gestures is coupled with the internal cortical motor representation of them', ibid

However, by way of caution, we have yet to explain the nature and significance of social situated interaction within a biological systems framework. However, of interest to the Cognition-in-Action framework are the findings that suggest a '*similarity in state between action, simulation and execution*' and the loci of their neural-correlates.

Fewer studies are concerned with the representation and/or recognition of biological motion, see Dittrich (1999). Grossman et al. (2008) is an example of the relatively limited work that examines neuro-atypical perception of biological motion. Later work by Buccino et al. (2018) re-examines the potential for action observation treatment to improve limb function in CP. Their findings support neural plasticity arguments and that these brain circuits subserve the impaired function rather than activating supplementary ones.

Such research highlights the importance of including neurology of action in the context of gesture to inform theoretical frameworks including the C-i-A framework. Specific brain regions implicated with neural mechanisms of imagery and intentional action are summarized to include:

i) supplementary motor area SMA and pre-supplementary area, prefrontal cortex (BA 44, BA9); ii) premotor area and primary motor cortex PMC; iii) inferior parietal cortex IPC and posterior parietal regions; iv) supplementary anterior cingulate cortex, insula, hippocampus, area 5, BA7, BA40; v) basal ganglia BG; vi) superior parietal lobule, precuneus, superior temporal gyrus and the cerebellum.

Most recently, both critiques and clarification of the limitations and computational potential of the MSH have been proposed. Technology-based neurological studies for gesture are more recent. I re-iterated that existing technology and paradigm are often inaccessible to neuro-atypical children with the severity of those that contributed to the child gesture corpus. Such studies have largely focused on isolated iconic and beat gesture forms, e.g. see Holle and Gunter (2007), Hubbard et al. (2009) and Obermeier et al. (2010). Interestingly, the planum temporale (PT) has been identified as a key site of multi-sensory integration.

I argue that the MSH and later hypothesis ILGM could be reinterpreted with evidence presented in my thesis for the Cognition-in-Action framework. Rather than arguments for a ‘*language ready brain*’, the alternative is proposed, that of an ‘*Action-Ready-Body*’ see Panayi et al. (2005). Arbib and Rizzolatti go on to argue for phylogeny, where stages are a coalescence of ‘*multiple changes*’ that form a ‘*global pattern that may emerge over the course of tens of millennia*’. These phylogenetic considerations are examined and discussed further in subsequent chapters of my thesis

However, as with medical models reviewed earlier in this chapter, the limitation of these studies is that they typically examine motor control in terms of functional action and the majority of this early work is based on animal models. There continues to be limited work that uses an inter-modal perspective. Tettamanti et al. (2005) focused on neural activation in relation to listening to action-related sentences whilst Iacoboni and Zaidel (2003) examined the need for visuo-motor integration in humans. The complexity of the inter-modal perspective is of particular interest.

2.3.8 Motor Control and Dynamic Systems

As early as the 1980s Kelso et al. (1981) reintroduce the idea of motor control as a dynamic system. Kelso later focused on the extended his concepts with mathematical formalization using Dynamical System Theory models, see Kelso et al. (1987); Kelso and Schöner (1987) and Scholz and Kelso (1989). For the implications for physical therapy, see Scholz (1990) and Scholz and Kubo (2008) and for children with cerebral palsy, see Scholz (1991).

Alternative models can be found in Kosslyn (1994b) and Hagoort (2005). These typically examine *dynamic*, *kinematic* and *physiological* performance respectively.

It should be noted here that the work of Kelso was influenced by the earlier sensor-physiology work and law of neuro-regulation of Uexküll (1904a, 1904b, 1905a cited by Rütting 2004). My work was also informed by biosemiotic aspects of Uexküll's in developing the C-i-A framework; see Panayi and Roy (2012). In the early 1990s Thelen and Smith (1994) were amongst the first to apply Dynamic System Theory to motor control including posture. They later extended this work to infant reaching paradigms, Thelen and Spencer (1998), and then applied *field theory* to ideas of embodied action, Thelen et al. (2001). Although not presented in this thesis, I have implemented a preliminary simulation using dynamic field theory mathematics for neuro-atypical movement, see Panayi (2010); an area for future development of the C-i-A framework. More recently, such mathematical treatments and experimental approaches have been applied to developmental explanation of neuro-typical infant looking and reaching paradigms; for examples, see Perone and Spencer (2013) and Spencer et al. (2014).

The systems approach I adopted in my thesis for understanding physically expressed intentional corporeality is timely. Particularly, when considered in the context of a recent movement science consensus paper by Caligiore et al. 2018. Their work is indicative of the trend towards interdisciplinary a systems-level view of motor control.

These authors agree:

'that viewing the cerebellum, basal ganglia, and cortex as an integrated system enables us to understand the function of these areas in radically different ways'...

In addition, they suggest that:

'future experimental and computational work is needed to understand the function of cerebellar-basal ganglia circuitry in both motor and non-motor functions.'

In terms of the implications for practice they highlight two main points;

'the integrative dynamics of the cerebello-basal ganglia-thalamo-cortical system is a vibrant and relatively new theme'

and that:

'further research and will likely require new network-based monitoring/therapeutic methods and systems-level computational models' *ibid.*

In the area of neuro-disability and motor control work, Hadders-Algra (2005) and (2010) has argued that we need to be able to match practice to the plasticity available in the infant's system. Her work uses a camera based system to identify infant movement profiles that can be used clinically for early diagnosis of CP. Hadders-Algra work has implications for re-

examining conventional notions of developmental movement trajectories. Especially in her work that re-emphasises the role of variation '*servicing exploration*', and the associated afferent information capacity to '*sculpt the development of the nervous system and less to adapt motor behavior*', only later '*servicing adaption*,' *ibid*. This work can be read to support my arguments for early intervention.

Hadders-Algra re-iterates that we know little about the nature of supra spinal networks that support motor variability. She goes on to argue that the approach of future studies should be to look at combining assessment techniques, including both observation and technology supported measurements such as multichannel EEG and/or EMG recordings, fMRI, Hadders-Algra (2018) p422. This work illustrates the value of looking at the variation in the movement repertoires of heterogeneous populations such as those illustrated in the case study presented in my research. In terms of the further quantitative analysis of human movement for the detection of CP, several authors propose the use of movement capture data analyses by applying various methodologies including examining K-parameter values under Tau Theory for details to differentiate healthy babies from undiagnosed cerebral palsy; for details see Mitchell et al. (2015).

Significantly, findings from the neuro-biological literature showed that both *imagined* and *executed* movements elicited increasingly similar activations; see Maksimenko et al. (2018) for an illustration of the application of non-linear method analysis of brain activity associated with motor action and imagery. A summary of such neuro-biological findings highlights the distributed nature of brain function facilitated by neuron differentiation. It also emphasises how severe disruption to key brain structures of the basal ganglia and cerebellum can have devastating effects on perception-cognition-action systems.

Motor control models that take a dynamic approach support the rationale that underpins the Cognition-in-Action framework. The C-i-A framework is described as a biological dynamic system with constraints. The case studies presented in Chapter 3 onwards illustrate how cerebral palsy children and adolescents are able not only to initiate but also control aspects of their corporeal movement during playful interactions with others. An analysis of movement components and meaning is presented in Chapter 4 onwards. The implications of my research are discussed further in Chapter 6 onwards.

2.4 Models of Gesture

In this third section I revisit conventional linguistically-grounded models of gesture as thought and as evidence of cognitive processes, *2.4.1 Models of Gesture*; *2.4.2 Conventional frameworks*; *2.4.3 Gesture as Thought, Spatial Knowledge and Metaphor*; *2.4.4 Alternative Perspectives*. I discuss their limitations within my biological definition of gesture. These models are placed within the context of emerging alternative perspectives. This section ends in *2.4.5* with a *Summary*.

2.4.1 Models of Gesture

I provide a critical review of conventional frameworks of gesture and selected empirical work that derives from them. The nature of action and gesture in pedagogy has a history influenced by the work of Inhelder (1956); Piaget (1962) and Luria (1934). Piaget's approach can be revisited and considered in biological terms, see Messerly (2009). I shall return to this argument in ensuing chapters. There is renewed interest particularly in mainstream education in research that provides evidence for both active participation and the use of gesture to enhance interaction and learning. For examples across age ranges and neuro-typical groups; see Rose and Fischer (2009), Goldin-Meadow (2010), Panayi and Roy (2012) and Hsien-sheng et al. (2018). Such models are discussed in the context of the C-i-A framework in ensuing chapters.

2.4.2 Conventional Frameworks

In this section conventional frameworks for gesture are placed in the context of their development over the last two decades. Paradigms used in *child gesture studies* are predominately derived from such frameworks, developmental psychology theory, and are heavily influenced by adult linguistic models of interaction that focus on co-speech gestures, e.g. see McNeill (1985) and (1992), Goldin-Meadow et al. (1993;2002;2003;2005and2009). What conventional linguistic approaches and such frameworks and models share in common is the fundamental proposition that executed speech and gesture are directly linked to two key features of mental representation; namely imagistic and motoric aspects that are generated during *language production*.

However, some of this work has developed protocols useful to examine gesture in child narratives, see Cassell (1989), Goldin-Meadow (2003) and Cassell and McNeill (2004). Importantly, these analyses do not view gesture as corporeal movement and the gesture sets

are typically limited in number and largely focus on types of hand gestures. Interestingly, Cassell's later work extended to the analysis of interactions with synthetic conversational agents and the issues of enriching our interdependence with such technologies, see Pecune et al. (2018)

Most cited is perhaps the early work of Kendon that proposed an evolution of gesture from gesticulation through language-like gesture to gestures that convey meaning through pantomimic action, through conventionalised emblems, to grammatical manual languages such as sign language. This continuum from gesticulation to sign languages is stylized in Figure 2.6 a) below and set against five of the most cited conventional gesture frameworks, Figure 2.6 b).

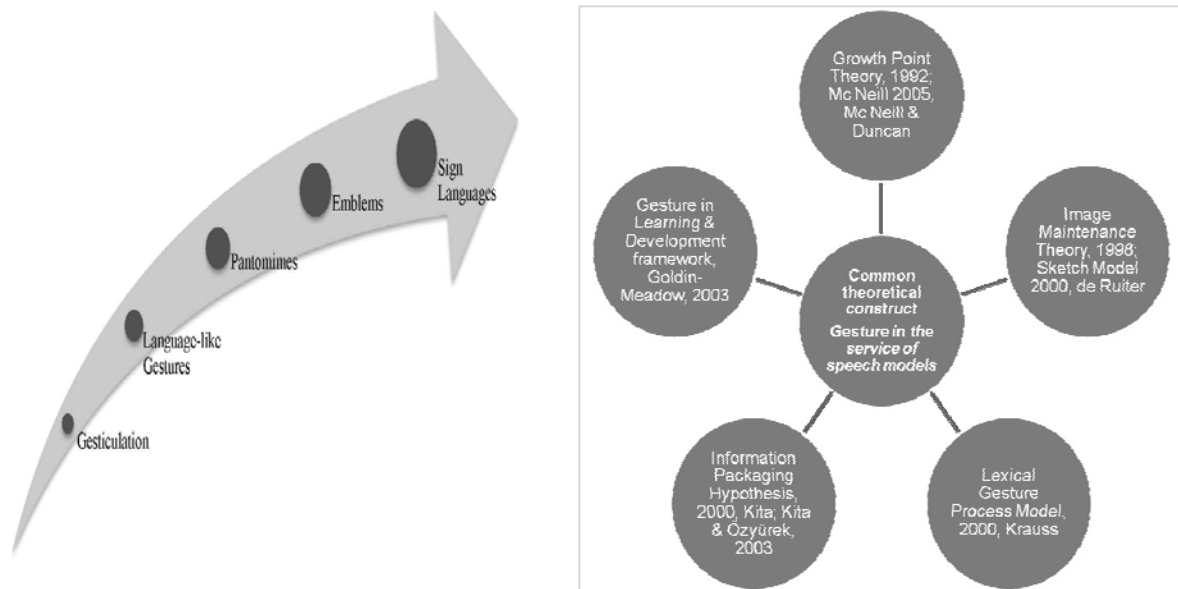


Figure 2.6 a) Kendon's gesture continuum (left) **Figure 2.6 b)** Shows five of the eight conventional gesture frameworks (right)

The typically cited conventional linguistic frameworks are presented in Figure 2.6 b). Chronologically they are: Goldin-Meadow's (2003) *Gesture in Learning & Development framework*; Kita (2000) *Information Packaging Hypothesis*; Kita and Özyürek (2003) *Interface Model*; Krauss et al. (2000) *Lexical Gesture Process Model*; McNeill (1992); McNeill and Duncan (2005) *Growth Point Theory* and de Ruiter (1998) *Image Maintenance Theory and Sketch Model* (2000); see Hostetter and Alibali (2008) for further details.

In 2004 Capone and McGregor provided a review of child gesture studies and a timeline of gesture development within conventional models of clinical practice. However, the degree to which the research is situated can vary considerably. For research under restricted laboratory conditions, see e.g. with neonates Meltzoff and Moore (1977), Meltzoff

(2007); Cook and Goldin-Meadow (2006) for work with infants. For later reviews of infant gesture studies and the impact of gesture on development in home settings, see Kirk (2009) and Andrén (2010). For field work based in wider community settings, see e.g. Sinha and Lopez (2000); in urban play settings, Goodwin (2000) and in the classroom Pine et al. (2004 and 2007).

2.4.3 Gesture as Spatial Knowledge and Metaphor

Although not considered in ecological or situated frameworks, work in the mid-1990s began to examine *paralinguistic coding*, i.e. talk and gesture in educational contexts, e.g. for science talk in the classroom, see Crowder (1996) and (1995; 2001). Later work by Lackoff and Nunez (2000) and Edwards (2003) explored such coding as children learn mathematics; aspects of their coding informed a subset of the categories of G-ABAS.

Seminal work by Johnson-Laird (1983) described how we *talk* about *spatial knowledge*. For work that considers the importance of cross-linguistic perspectives in spoken language and the role of space in language, see e.g. Bowerman (1996 a, b). Similar features have been examined in the domain of sign language by Liddell (2003). Slobin (2003; 2008) proposed the idea of gesture as a means for *thinking for speaking*. Manual languages (sign) fall outside the scope of my thesis; for further discussion see Goldin-Meadow and Mylander (1984) and Woll (2008).

Other work in gesture studies has highlighted the importance of gesture in building our notions of space through metaphor, see Müller (1998b) and Cienki and Müller (2006); Mittelberg (2006) and as visual embodiment, see Hostetter and Alibali (2008). More contemporary work by Mittelberg et al. (2013) is illustrative of the trends that look at gesture in cognitive–semiotic contexts and again as gesture in terms of iconicity, and metonymy is revisited, 2014 a; 2014b).

The nature of such studies still remains focused on the notion of ‘*gesture in the service of language (speech)*’. These frameworks are also limited as they use gesture annotation topologies limited to 5-6 types, largely restricted to the hands and face. The technology enhanced capture of movement is dealt with in another section.

Mention should be made of current state-of-the-art annotation systems for gesture. All systems are largely still heavily reliant on both manual segmentation of the gesture stream, labour intensive review and manual coding. The NEUROGES–ELAN system was developed in 2009 and is one of the favoured systems used to annotate multi-modal interaction, more

typically co-speech gesture. A review of 18 studies by Lausberg et al. (2015) found it to be ‘*a reliable system for the analysis of hand movement behavior and gesture, and its use across scientific disciplines characterizes it as an effective tool for interdisciplinary research,*’ (ibid. p19). However, the system has not been proven or used for the annotation of whole body corporeal movement. To date there are no examples of its use with the corporal repertoires involving neuro-atypical movements of children and young people with cerebral palsy.

Importantly, The GABAS and G-IPA annotation and analysis tools have the potential to be ported into almost any existing annotation software systems. This would require the development of numerous specific fields to be created. The advantage of such work would be that these systems could then become more inclusive.

Maouene et al. (2011) reviewed the role of embodiment in language; they challenged the basis on which imageability and frequency influence word learning. Specifically, they argue for a tight correlation of these features with body regions. I would extend their argument and propose that we clearly act or enact this knowledge. I develop this idea in the ensuing chapters of my thesis.

In terms of methodology, in developing the C-i-A framework I revisit methods that propose the use of *frame analysis* (Goffman, 1969 and 1974) and that focus on the nature of *interaction patterns of behaviour*, see Kendon (1972 and 1990). Schefflen (1972) proposed idea of the regulatory nature of *body kinesics* (actual body movement features) and Hall (1968) wrote about *proxemics* (distance relationships in interaction). These ideas were reconsidered within the contemporary notions of embodied interaction.

Revisiting the Language vs. Gesture debate

Within this context I re-examine the language vs. gesture debate and argue that conventional models still lack the robustness to inclusively consider my broader definition of gestural interaction. My definition encompasses not only the imaginative embodiment of gesture in communication but also the functional and creative nuances that make us human. Alternatives in terms of the concept of languaging as a process and the nature of embodiment in relation to body image and schema are discussed in ensuing chapters.

Kendon’s earlier work considers the relevance of *body motion* and speech (1972) which he later extends to ideas about the nature of space, time and gesture (1993a), and the use of tools (1993b). In 2008, Kendon revisited and reviewed the *language vs. gesture* debate and introduced the phrase ‘*languaging action*’ to encompass the ‘*multimodal character of*

expression both in sign and spoken languages'. He concludes with the significant recommendation that:

'we could work toward a comparative semiotics of kinesic expression and in doing so we could leave the debate about 'gesture' and 'sign' behind us' (Kendon, 2008, p.360).

In the same year, Hostetter and Alibali (2008) provided arguments and an extensive review of the literature, including neuroscience evidence from motor control studies that examine the role of mirror neurons and mental imagery in gesture. However, these studies can be classified as conventional representational views of gesture; see also Özyürek et al. (2007).

Importantly, Hostetter and Alibali place their Gesture Simulation Action (GSA Model) in the context of such conventional frameworks, although they do begin to consider gesture with an *embodied mind* paradigm. However, their model is still reliant on mental imagery explanations alone:

'all of the theories thus far are broadly compatible with the embodied view of cognition. That is, speaking involves the activation of mental images, images that rely on simulation of perception and action; gestures are an outward manifestation of these simulations. Expressing simulations through gesture may be a natural by-product of our thoughts, as Growth Point Theory contends.' (Hostetter and Alibali, 2008, p.24)

A limited number of research studies began to acknowledge the influence of action in child gesture development. Beilock and Goldin-Meadow (2010) argue that *gesture changes thought by grounding it in action*, see also Hostetter (2011).

In other research domains gesture is considered as embodied biomechanical phenomena but still within the conventional *perception-cognition-action cycle*, see Borghi and Cimatti (2009). For interaction with synthetic characters, e.g. child-like robots and virtual robots, see Kopp and Wachsmuth (2010). Their coding and synthesis bases still remain linked to conventional notions of gesture. Such studies fall outside the main scope of my review.

Some researchers have argued that the body contributes to language and embodied meaning more explicitly; they include: Glenberg and Kaschak (2003) and Glenberg et al. (2008). Klatzky and colleagues (2012), in particular, discussed the notions of embodiment in relation to ego-centric space and action. Vigliocco et al. (2004) acknowledge the need for intermodal connectivity in their *featural and unitary semantic space hypothesis* for the representation of word meanings, particularly those that relate to objects and actions. Interestingly, in a study by Pettenati et al. (2010), motoric characteristics derived from sign language were applied to representational gestures.

Mandler (1992 and 2004), an early proponent of representational schema, has revised her concept of spatial conceptualizations to consider dynamic aspects of integration; see

Mandler (2010) and (2013). In a similar vein, Karmiloff-Smith (2012) has begun to provide perspectives on the *dynamic development* of cognitive capacities in children, and Spelke et al. (2010) have argued for representation across *core knowledge systems* as underpinning our *concepts of space*. However, the theoretical underpinnings of their work still rely on linguistically bound explanations for the development of cognitive capacities.

The methodologies that underpin these types of studies also fall outside the scope of my review. However, a guide for methods used in child language based on conventional frameworks that are linguistically driven can be found in Hoff (2012). Cartmill et al. (2012) illustrate how such theoretical underpinnings influence practice in the following two statements, firstly:

'We suggest that it is only by examining speech and gesture together that language acquisition researchers can gain a full understanding of a child's communicative intentions and abilities.' (Cartmill et al. 2012, p.209)

and secondly, Cartmill and colleagues cite Goldin-Meadow and Mylander (1984):

'The first step in including gesture in a study of language acquisition is to isolate gesture from the ongoing stream of motor behaviour. We define gesture as a movement that is part of an intentional communicative act but is not a functional act in the real world', (ibid, p209)

I would argue that the latter of the two statements clearly illustrates the distance between conventional definitions of gesture and my definition. My definition encompasses not only the imaginative embodiment of gesture in communication but also the functional and creative nuances that make us human. Furthermore, the work and reviews discussed thus far do not include analysis of gestures or gestural development of neuro-atypical children with CP, and therefore fall outside the scope of this inquiry.

2.4.4 Alternative Perspectives

Embodiment of Languaging

This section briefly reviews selected literature that examines *languaging* as opposed to *language per se* and the notion of embodiment and its importance in human interaction.

Within a biological systems framework, what is important is the concept of '*languaging*'. Linguistic behaviour is regarded as *orienting behaviour*; language is derived through seamless interaction with the environment. I revisited the work of Siegler (2002) and Bronfenbrenner (1979) who re-examine child and human development respectively, within an ecological framework.

My thesis is timely, since the conventional conceptualisations of language to which gesture has previously been historically bound, are also being re-thought. In an edited work

Meyer et al. (2017) revisits ideas of intercorporeality in human interaction that echoes the transdisciplinary approach at the foundation of my thesis. As with my research, this work also draws upon the Merleau-Pontian concept of intercorporeality that transcends the object - subject divide. It provides further insight from both theoretical and developmental perspectives including meaning-making in interaction and the importance of objects. Interestingly, the notion of an integrated framework is mentioned but not presented.

In a special issue review in *Cortex*, Garcia and Ibáñez (2018) bring together literature that illustrates a significant and timely shift from not only '*action for language to language for action*' but also propose that '*embodied breakdown of language deficits as novel avenues into movement disorder*', *ibid*

Linguists are being urged to take a broader multi-modal approach to language. They are bringing into question the appropriateness of the spoken language analytical model being applied to manual languages. Of particular note is the call to include semiotic diversity, i.e. a consideration of both *language as an abstract system and Languaging*, Kendon (2017). From an ecological perspective in the field of radical cognitive science, boundaries are changing and researchers are suggesting that language be redefined as: *distributed ecological activity* where *wording* is a part. Vallee-Tourangeau & Tourangeau, (2014) focus on the importance of the spatio-temporal dynamics of systemic thinking and described it as cognition emerging in ecological space-time. Such situated activity involves not only our brains but also our motor actions and artefacts.

From the phenomenological cognitive science arena, sensorimotor schemes are being revised in terms of enactive paradigms. Bottineau argues for the fundamental role of sensorimotor interaction within an environment where;

'both the individual and the environment are modified, in which not one, but several individuals are involved – an experience that is, all in one, that of the speaker and hearer at the instant of uttering or thinking; that of the child developing into an adult through social intercourse; that of tribing turning into a full-fledged civilization', (Bottineau, 2010, p.268)

Bottineau provides an extended discussion of these concepts and instantiations within the enactive paradigm. In contrast, conventional language models regard linguistic communication as the *transmission of information*, which is reliant on *representational models*.

As an example of earlier work Gallagher (2005 and 2005a) and Stamenov (2005) made some discrimination between body image and body schema. They proposed an embodied approach to the body's influence on the mind. Although clearly an embodied approach, they do not give sufficient emphasis to the enactive role of the body. This can be contrasted with the biologically focused enactivist paradigm where language is considered an *'ongoing process that only exists as languaging, not as isolated items of behaviour'* (Maturana and Varela, 1992, p.210).

The fundamental difference between a biological systems approach and traditional models is that the latter are by necessity reductionist. In reductionist models, it is argued that tasks may require conscious detailed representation of movement and action. The Cognition-in-Action framework does not rely on representational explanation. I make the case for an *enactive* explanation which is discussed further in subsequent chapters of my thesis.

From a practice perspective it is worth returning to the metaphor of ecology; Siegler uses it to encapsulate his notion of child thought as;

'...more akin to an ecology of ideas, co-existing and competing with each other for use, than like a monolithic change from one stage of understanding to the next'..where...thinking is not a process that takes place 'behind' or underneath' bodily activity, but is the bodily activity itself,' cited by Rotman (2005, p.8).

I would suggest that such ecologies have the capacity to support alternative trajectories of development such as seen with young people with SSMI-CP. Bronfenbrenner (1979) (cited by Fischer et al. 1993 and 1995) critiques conventional studies of skill and argues that they show a *'marked underestimation of the natural diversity in developmental pathways'*. Previously, Bidell and Fischer (1992 and 1994) suggested the conceptualisation of *developmental webs* as opposed to stages and argued that conventional cognitive models were *'biased against the detection of diversity'* clearly apparent in cognitive development. They argue that *'detection of particulars of variability and diversity...allow for inference about process'* (Fischer et al. 1993, p51).

I take up this argument and show how it can also be applied to the context of clinical practice and research that considers the heterogeneous abilities and diverse developmental pathways of neuro-atypical children, see Panayi et al. (2005), Panayi, (2013). Work by Rose and Fischer (2009) also re-examines aspects of cognitive development within a neo-Piagetian model of learning, which incorporates Dynamic System Theory frameworks. The implications for learning in children with cerebral palsy are discussed in ensuing chapters;

see also Panayi and Roy (2012) where I discuss dynamic issues relevant to the *science of learning*.

The section of my critical literature review synthesis illustrates how such peripheral shifts in a conventional perspective could be aligned to my biological and enactivist framework. This not only justifies, but also strengthens the validation of the biological system theory approach put forward in my thesis. These alternative models are also discussed further in chapter 3 in the context of philosophical and biological frameworks.

2.4.5 Summary

The third section of the review outlined the main conventional conceptual frameworks used in gesture studies. The nature of such studies still remains one that focuses on the notion of ‘*gesture in the service of language*’, where language activities are largely focused around speech acts. In addition, I note that a large number of studies are laboratory based, with the exception of studies that take place in the home or school settings. In addition, existing annotation methods lack the depth of detail to facilitate fine-grain analysis of gesture within the construct of Cognition-in-Action.

Although the nature of action and gesture in pedagogy has a significant history, the conceptualisation of gesture as acts of action is only recently being reconsidered. Two research gaps in terms of inadequate interaction methodologies and models of embodied, enacted and extended interpersonal action are summarised in Box 2.7

- ❖ *the need for methodological paradigms that do not rely on normative explanations of gestural capacity and*
- ❖ *the research gap that exists for alternative models of gesture that better reflect the dynamic nature of motor action within the context of embodied, enacted and extended process of languaging*

Box 2.7 Research Gap -Inadequate interaction methodologies and models of embodied, enacted and extended interpersonal action

2.5 Executive Summary

The corporeal gestural phenomena that I examine clearly go beyond the brain. They are social and unfold both for the individual and groups across microgenetic, ontogenetic and phylogenetic timeframes. My thesis presents a Biological System Theory approach that is framed within the still emerging enactivist paradigm of cognitive neuroscience where the dynamic aspects of interaction are pivotal. However, we are still developing the theoretical foundations of this paradigm.

The relationships and dynamics, including the care of children and young people with cerebral palsy is complex and involve many people. The impact on their quality of life can be significant. The focus of my research at the theoretical and practical levels was to re-think not only the nature of intentionality but also how tools could be developed to capture and analyse such complex interactions. The working assumption is that such tools could then offer opportunities for more informed interactions that could impact on quality of lived experience for people with CP. The need for early intervention is well established, as is the need for interventions based on more rigorous scientific evidence for efficacy. I would argue that we should consider human interaction as a complex, dynamic and non-linear system. This operational definition allows for a reconsideration of conventional models and practices.

In my critical review I identify that there are limitation and gaps in research in the medical, linguistic and technology domains, specifically when considering corporeal expressivity of young people. More specifically, I have highlighted the case for children with severe speech and motor impairment due to cerebral palsy. Current research has yet to address the issues of how we can adequately motivate, elicit, capture, annotate/or interpret the intentional movement capacity in children. Similarly, applied research in computer science and the development of rehabilitation technologies are still addressing such issues.

In support of my approach the WHO ICY-CY classifications are now encouraging holistic approaches for the diagnosis and medical care of children with disAbilities. Conventional reductionist gesture models that largely rely on a concept of gesture as phenomena linked to and in the '*service to language*' were also being revisited. As they stand such frameworks clearly lack the capacity and rigour to offer an explanation for gestural interactivity in general and in particular for children with neuro-atypical profiles. I attempt to contribute to new knowledge in terms of: *elicitation methodologies, conceptual frameworks and annotation and interpretation tools*. Such psychometric tools have the potential to be developed to extend and be used as an adjunct to existing systems. I argue that conceptual

frameworks developed from as dynamic systems approaches can better inform a deeper understanding of child gesture. Furthermore, such research could support more holistic practices in the medical rehabilitation, pedagogic and technology design arenas. I ended the review by considering alternative perspectives and introduce the enactive paradigm for the development of a theoretical conceptual framework that is more ecologically valid.

This chapter serves as the first stage of validation for the biological systems theory approach of my thesis. The findings of my critical review underpinned the foci of the aims and objectives of my thesis. However, only work that is consistent with the biological, non-linear dynamic framework of the C-i-A framework is discussed further in the ensuing chapters. Finally, my review illustrates the significant challenge to rethinking complex systems with high levels of interconnectivity. The C-i-A framework and development of associated tools is offered as one timely alternative.

Chapter 3 Rethinking Gesture

3.1 Introduction Cognition-in-Action A Conceptual Framework

In this chapter I examine the philosophical perspective, biological system theory and performance practices that underpin the Cognition-in-Action framework. My framework is presented within a non-reductionist and non-representational paradigm. I identify candidate theories and experimental paradigms that are better suited to support a deeper phenomenological understanding of child gesture. This chapter addresses the first aim of my thesis and Objective 2: *To develop a theoretical framework that can support the re-conceptualization of emergent intentional action by children expressed as gesture.*

The Cognition-in-Action architecture is motivated against the notion of gesture as corporeal phenomena within a biological system of complex interactions. This chapter is presented as follows: in section 3.2 I introduce *Gesture as a Biological System within the context of the C-i-A architecture*; in 3.3 I consider *models of corporeal action* relevant to my definition of gesture. I examine *corporeality by considering theories and practice from antiquity to the present*. I revisit the *C-in-A architecture in terms of my theoretical synthesis* in section 3.4. The chapter ends with an *executive summary* in 3.5 where I summarise my arguments in favour of enactive phenomenological conceptual frameworks. I propose that they are better candidates for re-examining human intercorporeality as a dynamic and complex biological system.

3.1.1 Theoretical Background

The advantage of theoretical conceptual frameworks is that they are able to condense and provide coherence to bodies of related knowledge. Such models are able to describe, interrogate and simulate aspects of complex ideas and processes, as elaborated by Fuster (2007). He argues that *'We need theory and models or we do not understand what we find'*. Equally, the influences of our practice contribute to the development of our theoretical models. This idea is captured by Deleuze and Guattari, who argues that:

'Rather than conceiving practice as an application of theory, as its consequences, it is, on the contrary, the forerunner that inspires theory, the creator of a theory yet to come', (Deleuze and Guattari, 1994, p.49).

From a philosophical perspective, the work of Merleau-Ponty on intentionality and intercorporeality, Husserl's idea of knowledge as 'noema' (1913/1962) and Heidegger's notion of the importance of presence (*being there in time*) (1962), i.e. existence of 'Dasein',

provide the phenomenological focus for my work. This is complemented by work in the biological domain, specifically, the work of Maturana and Varela (1992). Here, I focus on their key notion of *knowing as doing*. This was later taken up by Bateson (1984) in the context of understanding *knowledge as action*. These notations are used and extended to include neuro-atypical unities. They provide the bridge for the construct I propose: that of *knowledge as cognition* and therefore *cognition as action*. This construct provided the starting point for developing my Cognition-in-Action theoretical framework.

I adapt Maturana and Varela's visual notation to describe intentional action rooted in gesture evolved through interaction across microgenetic, ontogenetic and phylogenetic timescales. The timescale aspect of the framework is influenced by the work of Donald (2007). He suggests an alternative mechanism for embodied and extended distributed cognition networks for transmission of knowledge within communities and an alternative intermediate form of memory. I discuss this further in Chapters 7 and 8.

From a bio-semiotic perspective, the work of Uexküll (1909) through to work of Meyerhold in the biomechanics of non-method acting, Decroux's notions of corporeal mime and Boal's work on forum theatre provide grounding for development of the idea of corporeal interaction. Such interactions take place within a sense-making subsystem which enables interaction with the social other.

The field of developmental psychology offers further evidence on how infants develop their sense of intersubjectivity. Reddy (2008) emphasises the significance of intersubjectivity from 1st person perspective in mother infant interaction. Sinha and Rodriguez (2008) argue for the importance of objects in infant interaction. Even in neuroscience Meltzoff and Decety (2003) and Decety et al. (2009) argue for social interaction and objects to be considered more seriously.

The field of anthropology and ecological psychology provide further perspectives on the role of tools and their relationships to gesture. Gibson (1966) proposes that optical arrays provide our affordances of objects. Leroi-Gourhan's (1993) seminal work on gesture and speech highlights the idea of an operational chain ('chaîne opératoire') to describe technological advances prehistorically. Goodwin (2000) and Hutchins and Palen (1998) provide child and adult examples of embodied and extended social interactions with object of play and work. However, the role of physicality and tangibility for children with cerebral palsy is still under-represented see Roy et al. (1996) and Panayi et al. (2000).

The ability to understand the self and others in space and time is fundamental to the evolution of interaction and learning. The *Dynamic System Theory* based work of, e.g. Amari and Arbib (1977); Kelso et al. (1988); Spencer and Schöner (2006) is considered in the context of neuro-biological studies that postulate mechanism of action. I discuss how the role of neural-correlate structures (Mirror System Hypothesis) has been influential but should be treated with caution see Rizzolatti et al. (1996) and Arbib et al. (2000) and more recently Oztop et al. (2014).

Contemporary work on neuro-dynamics includes the examination of neural oscillations conceptualised as neural fields, where characteristics of neural field activity are linked to cognitive functions, e.g. perception, action and learning see Freeman and Vitiello (2009). These mathematical approaches are identified as potential future dynamical methods that may assist in modelling the neuro-dynamic and bio-semiotic mechanisms of a science of intentionality and learning see Panayi and Roy (2012).

Most importantly, I identify the need for theoretical frameworks and analytical tools informed by practice that support three areas of study: corporeal interaction and social sense-making within complex system, the design of future pedagogic and rehabilitations practices and intimate technologies as described in Box 3.1 below

- ❖ *Re-examination of the Action-Ready-Body as core to corporeal interaction and sense-making within complex systems*
- ❖ *Development of future pedagogic and rehabilitation interactions and the*
- ❖ *Design of future intimate and perceptually sensitive technologies that acknowledge development trajectories as a web of alternative pathways*

Box 3.1 C-i-A framework four areas of study

The interdisciplinary systems approach of my thesis is validated in that it supports both the theoretical underpinnings of the C-i-A framework and the mixed methods approach adopted in my empirical study.

3.2 Gesture as Biological System

In this first section I introduce the propositions and constructs that underlie the *C-i-A architecture* in 3.2.1. My holistic phenomenological approach places the *Action-Ready-Body* within a *complex biological system* in 3.2.2.1 – 3.2.2.7. The C-i-A framework supports the study of alternative developmental trajectories that evolve through *sense-making interactions with social others and artefacts*. The section ends with a *summary* in 3.2.3.

3.2.1 Cognition-in-Action Architecture An introduction

In the sections that follow I introduce the Cognition-in-Action Architecture in the context of its theoretical underpinnings. The Cognition-in-Action conceptual framework supports both the exploration and development of children’s intentional action embodied as gesture. It prioritizes the capacity of the individual. It includes but is not restricted to the five foci summarised in Box 3.2 a) below.

- ❖ *Alternative motor profiles and developmental trajectories*
- ❖ *Functional movement and communication*
- ❖ *The complexity of interaction with self, the social other and artefacts*
- ❖ *Inclusive rather than deficit models of neuro-disability*
- ❖ *Holistic understanding of the underlying sub-system mechanisms*

Box 3.2 a) Five Foci of the C-in-A Framework

I consider key aspects of the conceptual framework within the context of the literature that influenced its development. I examine the notion of levels of system complexity and connectivity integrating philosophical, biological (including psychological) and technological (specifically performance practice) perspectives.

Propositions

Two propositions that underpin my proposed Cognition-in-Action conceptual framework are described in Box3.2b)

- ❖ **Proposition 1:** *Intentional actions as gesture are predominantly driven by the nature of our understanding of action in the world.*
- ❖ **Proposition 2:** *Knowledge of the world may be represented and explored through salient and afforded interaction schemata in relation to the self, social other and artefacts in our veridical, imaginary or hybrid worlds.*

Box 3.2 b) C-in-A framework propositions

I used the term *representation* to describe the phenomenon of encoding at a biological level see Barbieri (2003). I do not use it as a form of conventional conceptualization for re-

interpreting the world. A more detailed discussion of the term representation falls outside the scope of this thesis. Similarly, the term *schemata* is used to describe motor-directed activity related to interaction in the world that can be retained and modified by the nature of the connectivity between biological system elements.

Gesture-As-Action

The construct of *Gesture-As-Action* is proposed and denoted by Θ ; it facilitates the consideration of both complexity and the context of Θ (theta). Θ denotes a '*bounded and integrated gestural sub-system*'. The terms: θ^1 , θ^2 , and θ^3 structure three further propositions that describe aspects of a child's capacity as described in Box 3.2c).

- ❖ θ^1 *Conception, access and control of body action schemata for the self and social other including artefacts*
 - ❖ θ^2 *Use of inter-modal networks to encode for action in multi-sensory space and,*
 - ❖ θ^3 *Ability to execute dynamic transitions between the physical and conceptual world.*
- Box 3.2 c) C-in-A framework descriptions of Gesture-As-Action construct Θ**

Corporeal Knowledge Action Entities

Corporeal gestural knowledge is encapsulated as an *action entity* (AE). This construct describes cognition in terms of knowledge, where knowledge is in turn considered in terms of both embodied and exbodied action; thus motivating the term: *Cognition-in-Action*. Within the C-i-A framework these entities can be described in terms of their features. This notional construct of a *Gesture Action Entity* (GAE) is used to describe gestures in terms of their *Procedural*, *Semantic* and *Episodic* features. Three broad corporeal gestural knowledge categories are described in narrative terms. These GAEs can be considered as *perspectives of interaction* and are summarized in Box 3.2 d) below.

- ❖ ***Procedural Gesture Action Entities (P-GAE)***
Relate to gestural performance (i.e. corporeal dynamics)
 - ❖ ***Semantic Gesture Action Entities (S-GAE) and***
 - ❖ ***Episodic Gesture Action Entities (E-GAE)*** *Relate to meaning and experience often as stories or temporal events with personal salience (i.e. corporeal narrative).*
- Box 3.2 d) C-in-A framework descriptions of Gesture Action Entities**

Aspects of the C-i-A are instantiated and validated in the ensuing chapters of my thesis. Within a biological systems framework, this means that intentional action observed in child gesture can be considered as patterns that are *brought forth*, i.e. may become visible or are inferred as *entities of gestures*. When GAEs are brought forth explicitly they are *overt* and enacted in space or emulated when *covert*, but may become implicit. Henceforth GAE-EA,

refers to explicit Action and or those that remain hidden although they could be simulated (emulated), be imaginary and non-visible, but may be inferred, are henceforth referred to as GAE-SA.

The forms of gestural knowledge described are synthesised, recalled, reflected upon and expressed during interaction flow. My framework can be described as: *a non-hierarchical structure* of social interaction that supports societal subsystems. The *self* experiences the world from a 1st person perspective (the '*I*' or narrator or protagonist) often termed intra-personal or intrasubjective. The 2nd person perspective (the other 'you') and the 3rd person perspective (the 'it', 'he', 'she' or artefact) are described as interpersonal or intersubjective. I refer to this as one of the levels of *system connectivity*.

In the context of gestural interaction, first-person experience or perspective is that which is somatically experienced by the individual, whereas second person is that experience and perspective, and third-person can be equated with experience at distance, e.g. visually co-present or in technology supported interaction in imaginary or cyberspace. This concept of the interplay between veridical and imaginary interaction is influenced by the work of the philosopher Castoriadis (1987). He describes human interaction as an '*intersubjective network*', cited by Kavoulakos (2000), that supports imaginary elements shared by the society. These elements support the social-historical development of the group.

These corporeally expressed gestures are embodiments of the '*self*' in relation to the '*other*' (as social other person or artefact) and they are expressed through '*embodiment*'. Embodiment is the expression of a tangible or visible form of an idea, quality or feeling. Such actions can be equally embodied in our overt or explicit action. These interactions are derived from both experiential/explorative and reflective interaction. They are situated in veridical, imaginary, social imaginary and hybrid space. Figure 3.1 provides a schematic illustration of Corporeal Knowledge and the GAE's. It shows three inter-actors (two children and one adult) together with veridical artefacts (wheelchair, balloons). The bounded box represents the biological system and the ecological context for interaction.

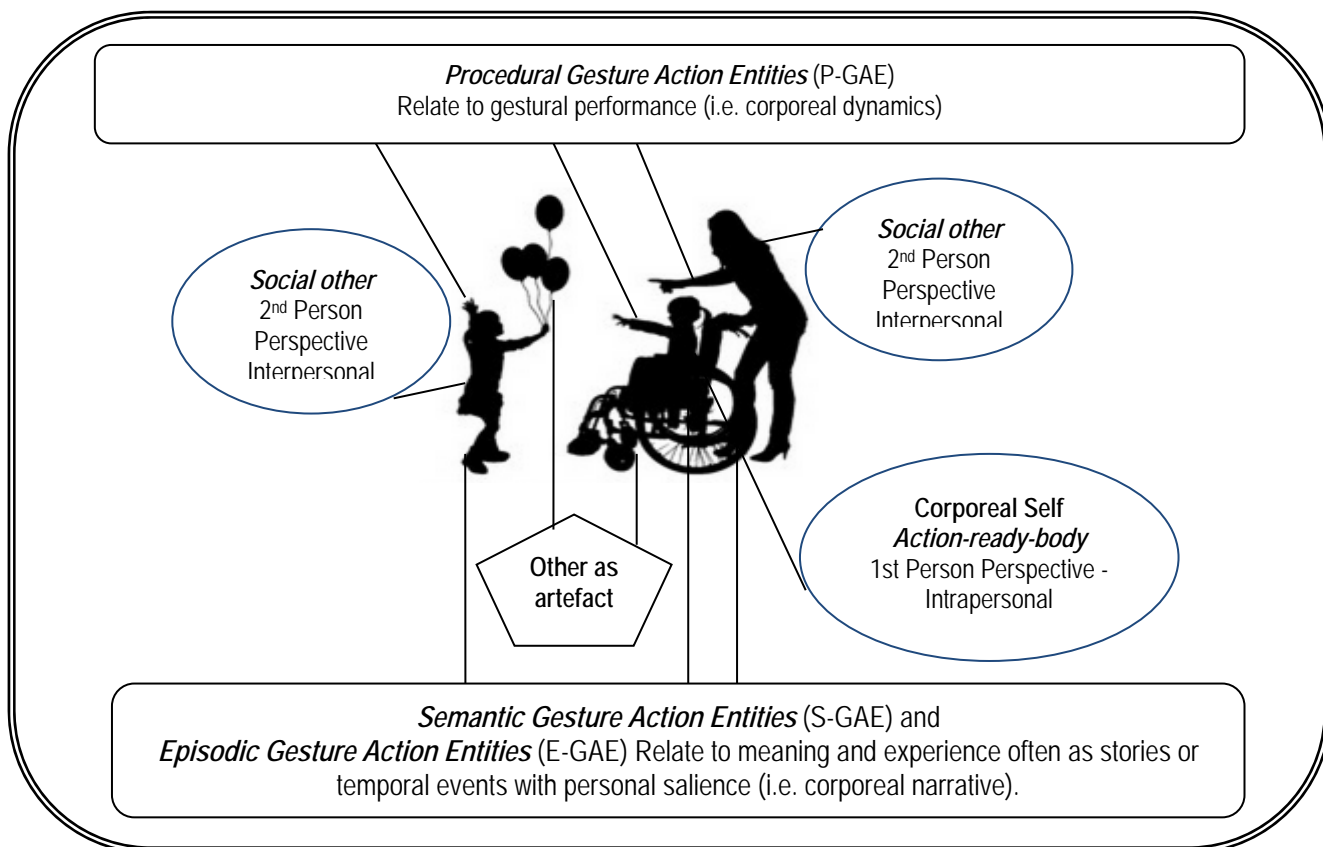


Figure 3.1 showing three inter-actors (two children and one adult) together with veridical artefacts (wheelchair, balloons). The bounded box represents the biological system and the ecological context for interaction. Original silhouette image credit copyright freewww.123rf.com

C-i-A and Tools

Six principal components of *C-in-A* framework action and mechanism components are summarised in Table 3.1 These components also form the bases for the ontological structure developed as a body based action annotation system (G-ABAS) tool.

C-i-A Action and Mechanism Components	Descriptor
Action Abstraction	<i>The ability to select a salient feature of action and synthesise an intentional act (intra-subjectivity)</i>
Action modulation	<i>The ability to modify action either on the 'fly' or over time</i>
Action integration	<i>The ability to integrate action. This ability is central to our understanding of ourselves as active agents within our bodies (internally) and externally (ex-bodied) in the world</i>
Action in relation to others	<i>Including the social other and artefacts that are manipulated or constructed (intersubjectivity)</i>
Action conceptualization	<i>The organization (coupling), re-organization (re-coupling) and access to schemata of actions that are fundamental to increasing complex development</i>
Mechanisms of actions	<i>By necessity supra-modal in terms of their neuro-dynamic nature, with their capacity for intermodal knowledge transfer, adaptivity and plasticity responses, i.e. bio-semiotic expression across microgenetic, ontogenetic and phylogenetic timeframes</i>

Table 3.1 C-i-A Components and associated descriptors

I examine both '*intrinsic data*' derived from an interest in the individual producing gesture and '*instrumental data*' created through analyses. This includes the abstract, i.e. zig-zag, denoted by the term θ^a and more concrete problems, e.g. the scenario 'pretend to steal a necklace' denoted by the term θ^b .

The G-ABAS can be used to inventory gesture movement; these annotations can be interpreted using phenomenological analyses adapted for gesture (G-IPA). These tools are introduced in chapter 5. The analyses of gestural exemplars are presented in chapter 6 onwards and support Aim 2 of my thesis.

My supra-modal model of *Cognition in Action* exemplified by child gesture is proposed as a hypothetical and dynamic construct for intervention planning in rehabilitation and pedagogy. It is discussed in subsequent chapters together with implications for the design of future augmented interaction for neuro-atypical children. The concept of a potential toolbox for the analysis and interpretation of child gesture is consistent with recent attempts in the clinical field to create a toolbox of functional measure for cerebral palsy children that are linked to the ICF model. This is embodied in Aim 3 of the thesis.

3.2.2 Action-Ready-Body

Ecology of Interaction

The Cognition-in-Action conceptual framework postulates that individuals interact to make *sense* of their world. This section introduces the term *bio-semiotic*, which refers to elements of the subsystem that are concerned with the *sense-making* aspects of interaction. I argue that such meanings can be embodied in gesture as *noemata* (Panayi and Roy, 2012). Their underlying *neuro-dynamic* mechanisms are influenced, but not necessarily driven, by their underlying neurology. I derive and summarise neurology of gesture in section 3.3.4.

Biosemitic is described by adopting the term *autonomous unity*. Autonomous unities operate in and are influenced by their own and the system dynamics. Their interaction can lead to individual change or *variation*. These variations can affect the group over time. The system can have *predictive capacity* through *coupling* of intentional agents within the system. Such a dynamic system operates within constraints, but can *bring-forth* emergent action and sustain variability. The ecological elements of C-i-A framework's system complexity are illustrated in Figure 3.2. In the sections that follow I discuss them each in turn.

The bio-semiotic, neuro-dynamic, societal and evolutionary subsystems are postulated to be nested within the overall system ecology. The dynamic nature of the system illustrates that system boundaries are largely descriptive. These theoretical underpinnings are consistent with the philosophical and biological influences of the conceptual framework that support the Cognition-in-Action construct.

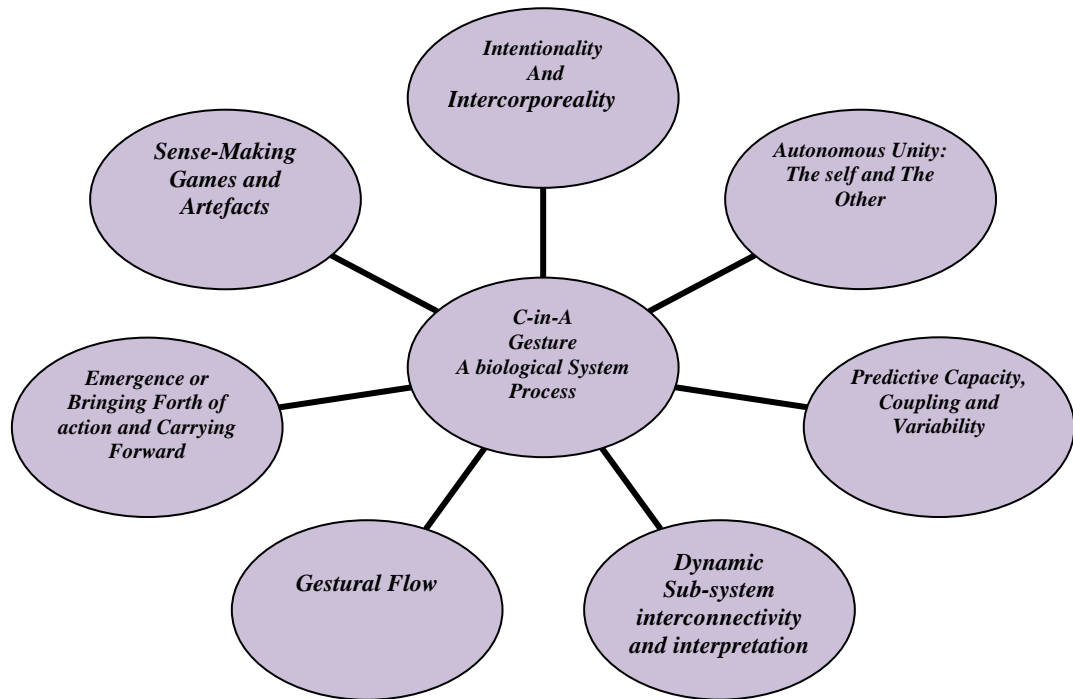


Figure 3.2 C-i-A schematic illustrating aspects of system complexity as an ecology of interactivity involving biosemiotic gestural flow see also Panayi and Roy (2005); Panayi (2012) and (2014).

3.2.2.1 Intentionality and Intercorporeality

Intentionality within a biological system can be described as being composed of essential elements. Human action is described as involving autonomous unities whose interactions with others have both purpose and the capacity to create meaning. I argue that Biological Systems Theory (BST) is a better candidate to underpin our understanding of the complex nature of the intentional action. I use the analyses and interpretation of embodied gesture exemplars of children with cerebral palsy to operationalize the C-i-A framework.

The notion of *intercorporeality* is inspired by the philosophical work of Merleau-Ponty (1964). He talks about *experience in imagination* and embodied by the self through intentional acts. He states that: “*The sensate body possesses “an art of interrogating the sensible according to its own wishes, an inspired exegesis”*”, (Merleau-Ponty, 1964, p.135).

Philosophically, the Cognition-in-Action framework focuses on the concept of enhanced lived experiences expressed through movement. Once again I draw upon the work of Merleau-Ponty who talks about the body being in a '*rhythm of existence... a 'living pulsation'*' (ibid p.148-149). He argues that these attributes bring meaning to our expressions and interactions. He sees gesture as an evolution through which interaction with others occurs and supports the development of our habits and skills. This is an attribute of gesture that I will return to in subsequent chapters of my thesis. I also examined Husserl's (1913/1962) concept of meaning, i.e. elements of structure of any intentional act through what he describes as '*noema*' as '*object, thought and perception*'.

3.2.2.2 Autonomous Unity: The Self and The Other

An individual *unity* can be described as being constituted as an autonomous, *dissipative* structure. A dissipative structure is one that exchanges energy and matter with its environment. Such an *open system* is characterised by the spontaneous *breaking of symmetry* and the formation of complex structures see Prigogine and Stengers (1984).

The C-i-A framework makes arguments for this *breaking of symmetry* as a phenomenon that can happen at the microgenetic level, enabling the emergence of novel intentional action embodied in child gestures see Panayi (2012). In the case of neuro-atypical young people their systems operate within significant *constraints*. These can be determined through the biological structure of the self, genetic and/or system constraints that arise through interaction. A case in point is the cerebral palsy child and their lived experience with social other and others as artefact.

3.2.2.3 Predictive Capacity, Coupling and Variability

Within this alternative biological conceptualization of intentional action, I describe the dynamic system that is driven by *regulatory* or *homeostatic forces*, rather than being driven by a purely *stimulus-response* paradigm proposed by conventional models of the perception-action-cognition cycle. Historically, this could have been described as a type of *conspicifcs*, i.e. behaviour related to and belonging to a particular species; for early discussion of the concept within a species context, see Darwin (1872/1965). For an explanation that includes the role of motor action in relation to *conspicifcs*, see Wilson and Knoblich (2005). Further discussion here falls outside the scope of my thesis.

Importantly, such dynamic systems develop *predictive capacity* through their *coupling* with both the environment, the social other and the other as artefact. This capacity not only allows for the interpretation of the behaviour of others, but it can include the

intention of others in relation to the *self* and can influence our interaction with the other mediated by artefacts. The ability to actively predict, and respond to unpredictable circumstance, i.e. *perturbations* within a system, provides the individual with the capacity for both *variability*, i.e. within individual action, and *variation* between the actions of individuals.

These ideas of variability and variation of action are discussed further in the context of both the heterogeneity of enactive performance of children and in the context of motor control in children with cerebral palsy, see chapter 6 onwards.

3.2.2.4 Dynamic Sub-system Interconnectivity and Interpretation

Biological systems are necessarily complex; often the nature of their interconnectivity is not fully understood. I use three concepts to frame the dynamic sub-system interconnectivity and interpretation within the C-i-A framework, namely: the biological metaphor of the '*rhizome*', the notion of '*organic coding*' and concepts from the field of *Biosemosis*. The detailed neuro-dynamic aspects of the interaction fall outside the scope of my thesis see Panayi and Roy (2012) and Panayi (2010 and 2014).

Rhizome

I re-use the biological metaphor of a '*rhizome*' to indicate the complex nature of connectivity sub-systems. Within the research domain it can also be used to describe non-hierarchical '*entry and exit points in data representation and interpretation*'. Biologically, a rhizome is a horizontal type of plant growth with lateral shoots. This term is also used philosophically by Deleuze and Guattari (1994) to describe models of culture that allow for multiplicities.

Organic coding

I argue that there is potential in exploring Barbieri's (2003 and 2010) notion of '*organic*' coding within such biosemiotic systems as an alternative explanation for representation. A promising approach is highlighted by Rączaszek-Leonardi (2012). Building on early work by Pattee (1972) on language symbols, she re-interprets the nature of language as arbitrary features in the context of enactive cognitive science. Specifically, they are defined as *physical structures* that become a boundary condition because of their history in the system, including natural selection. Such symbol structures operate within constraints but are replicable and therefore transmittable, thus achieving their adaptive functions or meanings. In Pattee's definition functional processes (in the biological sense) and codes suggests that '*the fundamental processes of interpretations may be similar throughout*

evolution'. Although he is commenting in the context of our attempts to understand genetic and human symbols (e.g. language), his work is directly relevant to my work on intentional action. Using biological level descriptions he defines all *functional processes resulting from symbolic constraint of dynamics as an agent's interpretation of the symbolic information*. This is contextualized for a code as *a synaptic mapping that (like coping) is independent of interpretations*. Pattee summarises at least six common features that he considers to be characteristic of all processes of symbols interpretation. I have shown the relevance of these characteristics by instantiating each with an example from the gesture repertoires of young people with severe speech and motor impairment. This has been done within the context of the C-i-A conceptual framework where gesture is conceived as a biological system, see Panayi and Roy (2012) and Panayi (2014) and Panayi, in prep.

These alternative explanations make redundant the need to evoke representational explanation for aspects of the traditional conceptions of the perception-cognition-action cycle. Thus, my framework allows for interpretation without the need for conventional representations when talking about cognition.

Biosemosis

My C-i-A framework is described at the theoretical system level in terms of the ecology of interacting subsystems both within the organism (endo-semiotic) and external to the organism (exo-semiotic). The notion of internal perception, '*Umwelt*', and internal 'images' on the system, '*Innerwelt*', are considered to guide activity in *semiotic niches*. These terms are incorporated from the theoretical biology work of Uexküll (1921). In contradiction to mainstream ideas in biology at the time, he advocated that the autonomy of an organism should be foremost. He described an organism as an interactive holistic unit with purposeful abilities that enable it to integrate into complex environments. Furthermore, that subjectivity should be the '*object of the scientific method*', see Ruting (in press) for a comprehensive overview of Uexküll's work. As mentioned in chapter 2, Uexküll's ideas were to influence both the Biological System Theory of Von Bertalanffy (1950s) and work in semiotics by Sebeok (1979). Later work by Sebeok and Umiker-Sebeok (1992) emphasises the importance of the visual aspect of semiotic interaction. Uexküll is now considered a pioneer of semiotic approaches to biology for a review see Kull (2001).

Hoffmeyer (2004) takes up Uexküll's notion of *Umwelt* within an ecological context and aligns it to contemporary ideas of system complexity using endo/exo-semiotic terminology. Importantly, he re-interprets and re-frames the ideas of selection from a

biosemiotic point of view as a '*selection force.... itself blind and only gets direction through the semiotic potential inherent to living systems.*' ibid, p10. He goes on to argue that;

'since these environments mostly consist of other organisms, an elaborate intra-as well as inter-specific semiotic dynamic is established from the very beginning of life around the organism's needs. Only because of this semiotic dynamic does the evolutionary process have direction and creativity' ibid, p10.

Interestingly, Hoffmeyer extends the argument to explain both holistic intentionality and goals. Firstly, he states that holistic intentionality cannot be explained '*reductively through an account of selective tunings of myriad of biochemical processes characteristic for the efficient operation of the individual self-interest*', ibid, p11; secondly, that individual organisms '*do in fact have goals..., but these goals are irreducibly bound to the whole biosemiotic setting.*' However, the nature of these settings arises as a '*product of endless diversification of holistic patterns,*' (ibid, p.11).

Finally, Hoffmeyer makes the case for the patterns themselves facilitating trends toward increased diversity, i.e. lost opportunity that gives rise to increased dimensionality. As part of this notion dimensionality he raises the open question of how *Umwelt* is experienced through the complex multi-cellular organism and how this may be affected by emotions. I would argue that within the C-i-A framework by having the capacity to make biosemiotic connections, meaning can be created at any level of the system or subsystem.

Furthermore, I propose that these biosemiotic and neuro-dynamic patterns are examples of features that reveal the nature of biological system that has *nested* subsystems. These operate throughout the ecology of *interaction* and contribute to the complex interconnectivity of the system. Such biosemiotic and phenomenological arguments lend further support to the rationale for the interdisciplinary approach that I take in my thesis and the foci of my aims and objectives. I return to some of these open questions in the analysis and interpretation of child gesture.

3.2.2.5 Gestural Flow

I chose to describe aspects of the *dynamic interactivity* of the system as a type of interaction flow. This notion of flow is derivative of Csíkszentmihályi proposed first a notion of *flow* (1975) and Csíkszentmihályi et al.'s (2005) principles of *flow*. They argue *flow* provides a means of '*understanding experience during which individuals are fully involved in the present moment*' (Nakamura and Csíkszentmihályi, 2005, p.89). Csíkszentmihályi examined this notion in the context of '*play and games, where intrinsic rewards are salient*' ibid (1975). This conceptualization is consistent with the intrinsically motivated interaction

paradigms examined in my thesis, see empirical study chapter 4 onwards. Importantly, these authors identify that *'no systematic empirical research had been undertaken to clarify the subjective phenomenology of intrinsically motivated activity'*, (Nakamura and Csíkszentmihályi, 2005, p.89).

In a similar vein, Varela and Shear (1999) emphasise the need for first person methodologies. They describe human experience as a phenomenon that is not fixed or pre-delineated, but is *'changing, changeable and fluid'* (ibid, p.14). This is consistent with both Csíkszentmihályi et al.'s work on experiential flow (1988, 2005) and Arzubiaga et al. (2008) on ecologically valid practices see Chapter 1. Furthermore, Varela and Shear propose that phenomenal data are *'valid intersubjective items of knowledge'*.

Finally, such research informed both the conceptualization of *optimal experience* and *development* and to emphasise the need for first and second person methodologies. In terms of optimal experience this is re-interpreted in my thesis in terms of biological system dynamics see Panayi (2012). At a theoretical level I use these concepts to support the concept of system connectivity in the C-i-A framework. At a practitioner level I use this and other works to inform the development of templates and guidelines that can be used by practitioner/researchers in the field see Chapters 6 and 7.

3.2.2.6 Emergence or Bringing Forth and Carrying Forward

Bringing Forth

The structural coupling that underpins interaction allows for the *emergence* or *bringing forth* of *adaptive* behaviour within the system. It is critical not only for species survival, but also as a mechanism for *making sense* of the world. This notion of *bring-forth* adaptive behaviour derives from the work of biologists Maturana and Varela (1974).

The enactivist theoretical approach proposed by Maturana and Varela serves to reformulate the mind from a biological perspective, i.e. *knowing as doing*. As such it makes a good candidate to theoretically situate the Cognition-in-Action framework. This notion of *knowing as doing* was later taken up by Bateson (1984) in the context of understanding *knowledge as action*. In essence, these approaches explore the interactional influence of the organism as an embodied *'unity'* with its environment. Citing von Bertalanffy (1960), they restate this as a system where *'there are elements of the organisation that subordinates each part to the whole and makes the organism a 'unity'*, (ibid, p.6). It is through interaction that such *'unities'* can *'realize a network of processes'*, which allows for both its *operational*

closure and *adaptive* interactions with the environment that support self-creation. This biological approach links *structure*, *mechanism* and *function*, as an *autopoietic* system.

The Cognition-in-Action framework combines this enactivist theoretical approach with Biological System Theory to provide a more holistic starting point for understanding child gesture. When compared to medical models described in chapter 2 it clearly brings together body structure/function, activity, participation and contextual factors in a holistic conceptual framework.

Maturana and Varela's works raise three important questions, which are of direct relevance to the aims of my thesis; these are summarized in Box 3.2.e) below

- ❖ *How does this unity arise?*
- ❖ *To what extent must it be considered a property of the organisation of the organism as opposed to a property emerging from its mode of life? and*
- ❖ *How does the living organism give rise to cognition in general and to self-regulation in particular?*

Box 3.2 e) The nature of unity and its relevance to the C-i-A framework

The second and third questions are of direct relevance to Aim 1, i.e. to develop a deeper understanding of child gesture within the construct of Cognition-in-Action. The questions make it necessary to describe the extent of cognition and its relationship to an organism's neurology. Two working descriptions were proposed by Maturana and Varela in the 1970s, which are used as critical starting points for my reflection. Firstly,

'A cognitive system is a system whose organization defines a domain of interaction in which it can act with relevance to the maintenance of itself, and the process of cognition is the actual (inductive) acting or behaving in this domain. Living systems are cognitive systems, and living as a process is a process of cognition.' (Maturana and Varela 1992, p.13)

and secondly,

'The nervous system expands the cognitive domain of the living system by making possible interactions with 'pure relations'; it does not create cognition.' (Maturana and Varela 1992, p.13)

Maturana and Varela (1992) propose the term '*enactive*' to encompass what can be termed the interactive nature of knowledge within a biological framework. Fundamentally, enactivism is a biological reappraisal of philosophical debates on the nature of '*self*' and '*other*'. It considers features of dynamic (i.e. metabolic) and boundary (membrane) and extends these ideas across *microgenetic*, *ontogenetic* and *phylogenetic* timeframes. They argue that any scientific explanation of knowledge should distinguish four conditions; these conditions can be used to explain cognition. The aphorism they use is: '*All doing is knowing*,

all knowing is doing' (Maturana and Varela 1992, p.26). They clarify *knowing as action*, as *'operating effectively in the domain of existence of the living beings'* (ibid, 1992, p.29). Their four conditions and explanations to support investigations are stated in Box 3.2.f) below.

- ❖ *Describing the phenomenon (or phenomena) to be explained in a way acceptable to a body of observers*
- ❖ *Observing the phenomena*
- ❖ *Proposing a conceptual system capable of generating the phenomena to be explained in a way acceptable to a body of observers (explanatory framework)*
- ❖ *Obtaining from the conceptual system other phenomena not explicitly considered by that (those) propositions*

Box 3.2 f) Four condition and explanations for 'All doing is knowing, all knowing is doing' (ibid, 1992, p.28)

These four conditions are motivated against the Cognition-in-Action framework in terms of the levels of operationalization and presented in Table 3.2; the left hand column summarizes the four conditions and explanations of the Maturana and Varela model. The right hand side of the table shows the operationalization within the C-i-A. This comparison illustrates the alignment and first level of validation of the C-i-A within a biological systems framework.

Maturana and Varela have proposed a visualization to illustrate their conceptualization of autonomous entities (see Figure 3.3). The organism is considered operationally a closed system. In the C-i-A framework I modified and extended this visualization to exemplify the interaction of entities that may have alternative life worlds and developmental trajectories, see chapter 6 onwards and Panayi (2014).

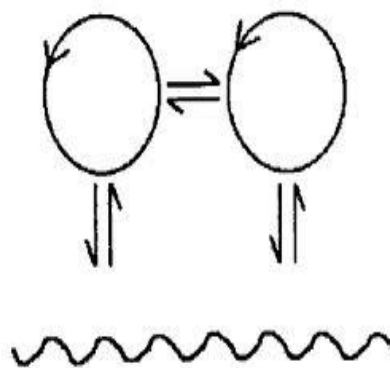


Figure 3.3 Maturana and Varela, (1992). The circle represents the living organism coupled to the other and the environment (wavy line). The interactions are bi-directional.

Autopoietic Model <i>(Maturana and Varela 1974/1992 p28/29 modified extract)</i>		Cognition-in-Action Conceptual framework <i>(previously referred to as SCA model, Panayi et al. (2005); Panayi and Roy (2012); Panayi (2013))</i>
Conditions	Explanation	Levels of Operationalization
Describing the phenomenon (or phenomena) to be explained in a way acceptable to a body of observers	Phenomenon to be explained: <i>the effective action of a living being in its environment</i>	<p>A theoretical framework for understanding the phenomena of cognition embodied in action rooted in gesture. Operationalized through empirical work <i>Ludic interaction paradigms</i> and analyses, see below.</p> <p>Observers include stakeholder communities for the research: co-participants and families, teachers, therapist, clinicians and academic peers</p>
Proposing a conceptual system capable of generating the phenomena to be explained in a way acceptable to a body of observers (explanatory hypothesis)	Explanatory hypothesis; autonomous organization of living beings: phylogenetic and ontogenetic drift with conservation of adaptation (structural coupling)	<p>Condition: Theoretical framework proposed for conceptualization.</p> <p>Constructs set out the scope for exploration used in qualitative case study</p> <p>Scale of interaction observation is microgenetic, theoretically developed for ontogenetic and phylogenetic levels</p>
Obtaining from the conceptual system, other phenomena not explicitly considered by that (those) propositions		Future work
Observing the phenomena (linked to description of phenomena)	Further observations: social phenomena, linguistic domains, language and self-consciousness	<p>Condition: challenges of eliciting child gesture, includes design of inclusive ludic interaction paradigms</p> <p>Explanation: Interaction paradigm extended to other ecologically valid scenarios.</p> <p>Includes the development of two analyses tools; A <i>body-based action annotation system (G-ABAS)</i> able to code for features and <i>Interpretive Phenomenological Analysis adapted from text for gesture (G-IPA)</i></p>

Table 3.2 Motivation and operationalization of Maturana and Varela’s autopoietic model in relation to the Cognition-in-Action conceptual framework and analysis tools

Carrying-Forward

I then considered Gendlin's re-definition of an organism's consciousness as one of process, where: '*consciousness is the self-sentience of making and re-making itself-and-its-environment*' (Gendlin 1999, p.234). In particular, he argues for an alteration in our assumptions of what we mean by imagery; from a *representation* to bodily change that lives an *image-event*. That is imagery as a '*special kind of bodily living in an environment*'. These images or image-events can be the source of what he calls '*felt-sense*', influencing '*holistic body change*'. Thus, the body is inherently '*an interactional process so body, emotion, situation, action, and other people are always inherently a single system*' (Gendlin, 1980). Such conceptualizations allow activity *brought-forth* in the Maturana and Varela sense, to be '*carrying forward*' in the Gendlinian sense.

Furthermore, Gendlin's ecological perspective on methodologies uses a frame of reference where *contents* can both arise through bodily process and change within these processes. Importantly, humans are '*capable of an immense variety of kinds of processes, and thereby also kinds of 'self', kinds of 'contents' and kinds of observable results*' (ibid p.237).

These kinds of selves and contents are revealed in my analyses and interpretation of cerebral palsy child gestures. Through their enacted gestures young people with cerebral palsy reveal featural aspects of their imaginary, veridical and hybrid world experiences. They bring forth their intentionality by harnessing and modifying what are often complex physical and tangible performance strategies. These actions and types of interaction have not previously been seen or documented.

Within my C-i-A conceptual framework I take the Gendlinian notions of holistic change that arises out of *felt-sense* and consider them in the context of gestural process. Firstly, intentionality drives the *bringing-forth* of gesture which can then be *carried forward* through improvisation. I later apply my framework to interpret the enacted gestures of young people with cerebral palsy.

3.2.2.7 Sense-Making Games and Artefacts

Ludic Interaction: A Special Sort of Sense-Making

The role and importance of play finds its roots in the philosophical work of James (1880).

He places the self within what he terms active '*combinatory play*'. He states that:

'in a word, we seem suddenly introduced into a seething cauldron of ideas, where everything is fizzing and bobbling about in a state of bewildering activity, where partnerships can be joined or loosened in an instant, treadmill routine is unknown, and the unexpected seems only law' (James, 1880, p.456.)

The play paradigm that supports the children's co-participation to enact gesture was also grounded and influenced by the nature of motivational engagement within ludic (play) interactions see Huizinga (1950). I describe the two main features that are thought to underlie sense-making for children; these are stated in Box 3.2 g)

- ❖ *Conceptual structures and resources and*
- ❖ *Neuro-correlate substrate architectures.*

Box 3.2.g) C-i-A Features that underlie gestural sense-making in children

My focus on conceptual structures draws upon descriptions used by Goodwin (2000) in his work on interactive construction of talk, i.e. *talk-in-interaction*. He and his colleagues illustrate the concept using scenarios both of children playing the game hopscotch and work place artefacts used by archaeologists, i.e. a mansard soil colour chart. They describe both the rules and the role of the artefacts as *semiotic structures and resources* whose configuration form a *semiotic field*. Such terms have been incorporated into the C-in-A architecture, see Figure 3.5. In my thesis they are discussed using gesture exemplars of children with cerebral palsy.

In terms of neural-correlates I offer a derived *neurology of gesture* that indicates where we think processing of action, imagery and objects is located. This neurology is included as it supports the supra model underpinnings of the Cognition-in-Action conceptual framework.

Exemplars from the Child Gesture Corpus are presented through selected case studies and discussed within the context of micro-genetic system change see chapter 6 onwards. These gestures form part of a gesture corpus established by Roy et al. (1992); Roy (1996). Gesture repertoires from other neuro-atypical and neuro-typical children were added to this corpus by the author of this thesis. These are not reported in my thesis. Details can be found in the appendices and reported in Panayi et al. (1995); Panayi et al. (1998) and Panayi et al. (2000); Panayi and Roy (2012) and Panayi (2013).

My analysis provides evidence from the microgenetic level within the system i.e. *moment-to-moment interaction*. This is achieved through the microanalysis and interpretative examination of these exemplars. It should be noted that prior to their interaction in these ludic games the gesture repertoires from children with severe speech and motor impairment due to cerebral palsy had not previously been reported, see Roy et al. (1992); Roy (1996); Panayi et al. (1998).

Participatory Design and Co-participation

The original study by Roy (1996) was informed by the co-participating children, their parents, teachers, therapists, paediatricians and physicians, i.e. pink; green; purple and blue spheres, see Figure 2.1 in chapter 2. The ecologically valid approach of the empirical case study involved previous work with children as *active co-participants*.

The design of the interaction methodology was influenced by participatory practices in the domains of *pedagogy*, *performance art* and *human computer interaction design*. Specifically, I was influenced by the inclusive and critical pedagogic practice of Freire (1973), who elaborated a philosophy informed by the children's experiences of extreme poverty. He viewed this as a form of oppression. His work was later to inspire the work in theatre of Augusto Boal (1995). To my knowledge no previous study has explicitly investigated the nature of co-participatory design with severely impaired neuro-atypical children, although Siegel-Causey and Guess's (1989) work is illustrative of practice that advocates pedagogic principles of '*learning through doing*'. Similarly, the work of Scherer (2000), although relating to adults, is relevant. She analyses the impact of assistive technology and included the phenomenon of '*technology abandonment*'.

Returning to the domain of theatre, Boal (1995) trained actors and communities in a theatre philosophy and practice where the spectator can interrupt the theatrical action and drive the creative process. This practice underscored the interaction paradigm developed for the elicitation of child gesture. This empowering notion of participation is fundamental to my methodological practice. My methodology is based on supporting purposeful sense-making experiences for children.

I previously successfully applied this methodological paradigm in the domain of human computer interaction design with children. Work in this domain was also influenced by the work of Lipman (2003), who created a practice of '*communities of inquiry*' (CoI) when working with children. His work was influenced by the earlier work of Lave (1988) and Lave and Wagner (1991) that brought stakeholders together to create '*Communities Of Practice*' (CoP) to explore the potential for system change. Further influences came from adult human-computer-interaction and interface design by Ehn and Kyng (1991). Details of my Situated-Interaction-Design (SID) methodology are reported elsewhere; see Roy (1996); Panayi et al. (1998); and Panayi et al. (2000).

I mention these examples since Aim 3 of my thesis is concerned with the development of guidelines that illustrate how a better informed framework and ecologically sensitive practices can support future work with neuro-atypical young people. Such paradigms would offer alternatives to current practices, a research and clinical gap identified in my review.

Artefacts, Affordance

The importance of artefacts in human-human interaction is one that is under-represented in the extant literature. Even in the domain of developmental psychology relatively little attention has been paid to the significance of artefacts in the development of child cognition or gesture. Recently, Sinha and Rodriguez (2008) explored the relationships of language to objects in infant studies. For earlier work on the importance of how infants experience intersubjectivity and perspective taking, see Reddy and Trevarthen (2004) and Reddy (2008). All three case studies in my thesis consider the role of either veridical or imaginary artefacts in the context of gestural interaction.

I have reviewed literature in the domain of neuroscience in relation to object recognition. The research gap here lies not only in the limited literature that examines child neurology in relation to interaction with objects, but also in the theoretical underpinnings and limitation of neuroscience methodologies as discussed in my review in Chapter 2. However, in section 3.3.4, I re-summarise key literature that provides the basis for a derived neurology of gesture.

Anthropological Perspective on Gesture and Artefact

From the field of anthropology, early work by Bateson and Mead (1942) focused on the cultural significance of gesture and posture, whereas later work by Ruesch and Kees (1956) considered non-verbal communication in three domains: *pictorial*, *action* and *object*.

The seminal work on gesture by archaeologist and anthropologist Leroi-Gourhan (1993) gives a detailed historical and evolutionary consideration of the role of artefacts and actions including gesture and their significance in such interactions. He introduces the idea of an operational chain (*chaîne opératoire*) to describe technological advances prehistorically. He proposes an '*interpose membrane*' and '*artificial envelope*' for the use of technologies, including tools in human society.

Of particular interest to the development of my annotations and interpretation tools are the approaches used by Jousse (1997 and 2001) and Birdwhistell (1952 and 1970) who introduce the notions of *units of memory* stored and replayed as *mimemes* and *kinemes* as morphemes of gesture, respectively. The work of Jousse in particular pre-dates contemporary

notions of the *meme*, which are postulated as ‘units’ that transmit culture through artefacts such as ideas, symbols and practices. For opposing discussions on the notion of memes, see Dawkins (1982). A discussion of Dawkin’s notion of memes falls outside the scope of my thesis. However, I have considered Kull’s (2001) arguments for the transmission of culture through the notion of entities within a biological biosemiotic context see 3.2.2.4.

I argue that such interactions create *sense-making* opportunities that are underpinned both by neurology and affordances. The notions of *perceptual affordance* have been described by Gibson (1966 and 1966a) within an ecological framework. Subsequently, Gibson and Pick (1979 and 2000) developed these ideas to explain aspects of infant development. Affordance is defined as ‘*quality of an object, or an environment, that allows an individual to perform an action*’. Furthermore, I would claim that this extends to the human capacity to interact with the other as veridical and imaginary artefact. A particularly promising approach that I classify as enactive is offered by the work of Donald (2007). He conceptualises cognition as a *distributed knowledge network* that operates in cultural niches. He describes the role of mimesis on the evolution of gesture and thereby possibilities for more sophisticated human cognition. He argues that it enabled:

‘*playacting, body language, precise imitation and gesture*’...’*as mode of cultural expression and solidified group mentality, creating a cultural style that we still recognize as typically human*’ *ibid*, p.266.

He makes the significant observation and argument that:

‘*our capacity for skilled rehearsal is potentially creative because it can generate variation, that contributes to the overall range of acting in our social repertoire*’

Furthermore he convincingly argues that the cognitive core of mimesis is *kinematic imagination*. Such networks have the capacity to embody and give salience to artefacts and for knowledge to be transmitted across microgenetic, ontogenetic and phylogenetic timescales. Donald goes on to propose a model of ‘*intermediate memory*’ that I consider in the analysis and interpretation of child gesture. This is discussed further in ensuing chapters in the context of the C-i-A framework.

3.2.3 Summary

I began my arguments by proposing we re-consider gesture as a biological system. The notion of autonomous unity is placed at the core of interaction. I advocate that as humans we possess an *Action-Ready-Body*. I set the development of the C-i-A framework within the context of philosophical notions of *intercorporeal interaction* and thought as *noema*. I use biological metaphors for re-thinking *system connectivity*, *complexity* and representation as a form of *organic coding*. I systematically examine subsystem interconnectivity in terms of *biosemiotic* concepts and make the case for ludic interaction as a special sort of *sense-making*. These interactions through the process of *coupling* provide us with the capacity to *predict* and *adapt* our action, thus facilitating both *variability* and the advantage of diversity for survival.

I detail how interaction can be conceived as *Gestural flow* and how Cognition-in-Action can be described using the enactive paradigm of gesture being an *emergent phenomenon* that is *brought forth* and *carries forward* in social contexts.

I examine work from the domains of psychology and anthropology that re-focused my attention to the importance of *affordances*, *mimesis* and the *role of artefacts* in sustaining human, and in particular the development of infant relationships. I discuss the importance of gesture in our cultural evolution as these relationships unfold not only at the *microgenetic* level but across *ontogenetic* and *phylogenetic* time frames.

In the next section I extend my discussion to the influences of the art of oratory in antiquity, to contemporary practices in the performing arts, specifically corporeal physical theatre and narrative theory to the development of C-i-A framework. This includes revisiting the notion of sense making in performance contexts. Finally, I return to the neuroscience domain to derive neurology of gesture that supports the supramodal nature of gesture enaction within the C-i-A conceptual framework.

3.3 Models of Corporeal Action and Gesture

In this section I examine the *Art of Oratory* and its influence on the study of corporeal gesture. I provide a historic perspective to the nature of enactive expressivity. I would argue that this increases both the robustness of the conceptual framework for the construct Cognition-in-Action and the subsequent analyses of cerebral palsy gesture. My thesis offers a substantive alternative to both earlier and conventional treatments of such phenomena as - 'gesture in service to language' to one that explores *intentional action embodied as corporeal gesture*. My focus on corporeality aligns with the frames of reference and aims of my thesis. I consider this work against contemporary and largely western writings in research and practices in performance art, theatre and narrative theory that have influenced my conceptual framework in 3.3.1. I derive a *Neurology of Gesture* which underpins the neuroscience aspects of the C-i-A conceptual framework in 3.3.2. In section 3.3.3 I present a synthesis and explanation of the influences that informed the C-i-A Architecture. The chapter ends with a summary in 3.3.4.

3.3.1 *The Art of Oratory in Antiquity*

The corporeal nature of gesture has a long history, where the hand has been seen as a critical articulator. Some of the earliest references to the importance of gesture in communication have been elaborated by Quintilian in the 1400s. During antiquity the habits and skills of oratory through formalised gesture were clearly defined and taught. He does however; cite Cicero who emphasises the importance of the whole body of the orator and not just the hand

"There will be," in a consummate speaker, "no affected motions of the fingers, no fall of the fingers to suit the cadences of the language, but he will rather produce gestures by the movements of his whole body, and a manly inclination of his side." ibid Chapter 3

He goes on to elaborate that:

'gesture and motion are formed, so that the arms may be properly extended, that the action of the hands may not be ungraceful or unseemly, that the attitude may not be unbecoming, that there may be no awkwardness in advancing the feet, and that the head and eyes may not be at variance with the turn of the rest of the body.' ibid Chapter 11

In the 17th century Bacon identified the hand as a '*transient hieroglyph*'. During this time, Bulwer (1974, original work 1644) in his rhetoric of gesture '*Chirologia and Chironomia*' saw the hand as an instrument of eloquence. More interesting and less cited are his other

works including *'Pathomyotomia' or a Dissection of the Affections of the Minde* where he refocuses on the nature of the semiotic mind and body.

Other work that I examined included that of Gilbert Austin's (1806) *Chironomia*; Johann Jakob Engel's (1822) *Practical illustrations of rhetorical gesture and action*. Two historical works in particular influenced the development of the body action-based gesture annotation system. Firstly, Florence Adams's (1891) work on *Gesture and pantomime action*, and Thwing's (1876) analysis of vocal culture and gestural body movement. These works provided me with points of departure to reconsider corporeality. These are referenced in the appendices in relation to the G-ABAS.

3.3.2 Contemporary Performance Art, Theatre

In this section I reconsider the notion of intentional corporeality in the light of contemporary work in the Performance Arts. Specifically, I have chosen to consider two main art forms: that of *corporeal mime* in *physical theatre* as illustrated through the work of Meyerhold (see Bakshy 1916 and Pitches 2003), Decroux, (1985) and Lecoq (2000), and in dance the examination of the annotation system of Laban (1975) and Laban and Bartenieff (2000). Sheets-Johnstone, a dancer and philosopher describes how even our everyday movements depend on *'our resonant tactile-kinaesthetic body'* (1999, pp.143-146). Notions of *'developmental hyper-movement patterns'* and *'neuromuscular shape-shifting patterns'* in addition to *'effort'* used in Laban notation of dance have been incorporated into G-ABAS movement inventory, see appendices for codes.

Corporeal Mime

Biomechanical Method

I begin this section by introducing the work of Meyerhold who in the 1920s proposed an alternative to Stanislavsky's method-acting technique. It takes as its starting point the physiology of the body, more specifically the body biomechanics. It should be noted that from a theatre perspective his focus was not on theatre that recreated life. The underlying philosophical bases of his work fall outside the scope of this thesis. What is relevant to my thesis is his desire to examine the plasticity of movement and how this links to what he terms *'inner dialogues'*.

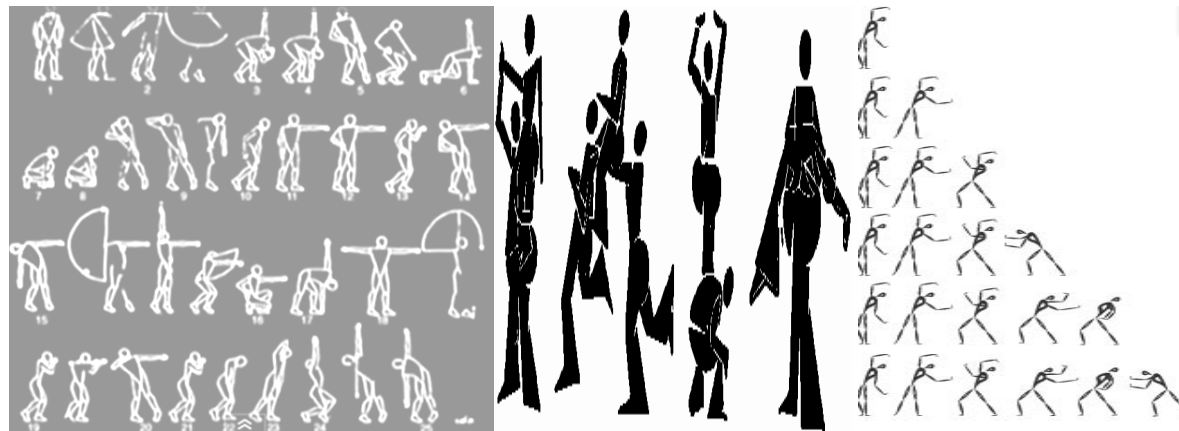
Meyerhold's method sees discrete movements as having four parts; they constitute the *Daktyl* described as a rhythmic movement including all parts of a biomechanical movement,

i.e. *otkas*, *posyl*, *stokia* and *tormos*. These parts have been described in Box 3.3 a)¹ below. Such movement sequences can be learnt as *Etudes*; importantly they involve kinaesthetic, spatial and relational awareness. A selection of these highly stylized pieces is illustrated in Box. 3.3 b) together with links to illustrative online video clips for biomechanics² and corporeal mime methods³.

One of the additional advantages of the biomechanical method is that emotion can be derived and stimulated from the physical activity, i.e. bodily form. It is important to note that the interaction methodologies used with children do however focus on emotional engagement and expressivity from the outset.

otkas (refusal): movement in preparation action, manifest in movement may be in the opposite direction, like a spring
posyl (the sending): actual extension of the intended action, set up by *otkas*
stokia (or stance): both the completion of the movement (coming to a halt) and the starting block of the next movement
tormos (the brake or resistance): it is that which helps the body move in a fluid and controlled motion through all stages of the movement.

Box 3.3 a) Meyerhold's biomechanics - An extract from 'About Vsevolod Meyerhold' 10.2.08
 Trans. E.Zafirovska



Box 3.3 b) Biomechanics Method, after Meyerhold, 1922 first two images from the left and image on right for illustrative positions from the work of Etienne Decroux

¹ <http://web.syr.edu/~kjbaum/aboutvsevolodmeyerhold>

² For Biomechanics work of Meyerhold see Bakshy (1916); <http://vimeo.com/23789512> ,
<http://cw.routledge.com/textbooks/actortraining/practitioner-meyerhold.asp>
http://oud.digischool.nl/ckv2/moderne/moderne/inleiding_files/vsevolod_meyerhold.htm

³ For illustrative work of Etienne Decroux see <http://www.youtube.com/watch?v=8b2Q8LVqVfY> Parts 1 -6 and
http://www.youtube.com/watch?v=_42KY2SAZgY for notions of Moving, Machine and Statue

Excitability and the Acting Cycle

Any actor has the capacity for ‘*reflex excitability*’. This excitability is described as the ability to realize feeling in movement and words which may be prescribed externally. For Meyerhold the *Acting cycle* has three parts: *intention, realization and reaction*.

He uses the notation of [N] to signify the intention and [R] reaction which he describes as self-presentational style. A1 is used for the actor who exists, or the *thinking conceptualizing actor* and what I would term the *pre-explicit action actor*, and A2 the actor who does not yet exist and who is ready to perform. For A2 he describes the actor as material to be worked upon which can be described as the *actor doing*. I have summarised this notion of excitability and descriptions of the acting cycle in Box 3.3.c) below.

Intention/Exposition: intellectual assimilation of task presented externally by dramatist or initiative of the performer. Intention gives a sense of distance and direction. [N]

Action Realization: cycle of volitional, mimetic and vocal action, attenuated in preparation of new intention whether explicit or not

Resolution/Reaction: reacting to real or imaginary event, reacting to space creates space. Distance giving a tool to contrast space. [R]

Described in Notation form as: $N=A1+A2$

Box 3.3.c) Meyerhold’s biomechanics adapted from ‘*About Vsevolod Meyerhold*’

Trans. E.Zafirovska and Pitches (2007) online

Role of the stage

Importantly, the actor’s performance is dependent on the size of their stage. Furthermore, Meyerhold goes on to develop his practice to de-construct the notion of the traditional stage and *mise en scene* to bring the method actor closer to the actor’s body and movement. For an analysis of *mise-en-scene* for child neuro-typical gesture repertoires produced in a retelling after viewing a video cartoon see Panayi (2012).

Forms and Meaning-Making

Both Meyerhold and Decroux advocated that corporeal performance provides opportunities for new meaning and thinking through the combination of elements of form. It facilitates a mind-body unity. The form types include *tempo, rhythm, attitude and raccoursi* (foreshortening) and *contrepoids*. Contrepoids describe the actual counterbalancing of the muscle that comes into play during the mime, the latter making the invisible – visible. Meyerhold emphasised the need to develop what he termed ‘*mirrorizing*’, a type of kinaesthetic vision. This also includes the ability to work with real and imaginary objects.

Examples from the ludic interaction gestures repertoire performed by neuro-atypical children could be, e.g. the *holding of a heavy/light weight, playing the violin, playing tennis*

and *riding a horse*. Foreshortening describes the minimal essence of movement in space. Within G-ABAS this is termed the *holistic gesture envelope*. Importantly, the attitude in corporeal mime can be described as the point at which body or body part is fixed in a momentary pose. There are many instances of *attitude* within, e.g. the charade gesture repertoires. The interaction between *contrepoids*, *attitude raccourci*, *tempo* and *rhythm* makes previously non-existent movement and imaginary objects ‘visible’. Finally, they both adhered to a ‘*principle of totality*’ where the corporeality meant that every movement needed to consider at minimum gravity, tension, release and rhythm.

Corporeal Mime and Physical theatre

Decroux describes corporeal mime as action where:

‘the prevalence of the trunk over the other parts of the body is fundamental. The actor, according to the Decrouxian model, becomes totally expressive and is no longer awkwardly limited to the overriding and uncontrolled use of the face and hands’, Decroux (1963).

Lecoq, in teaching creative theatre, equates mime with drawing as a physical act of *recreation* as opposed to *imitation* (ibid, p22). The philosophy behind Etienne Decroux’s physical theatre method focuses on the challenge of transforming ideas into physical reality. His method successfully ‘*makes visible the invisible*’ through metaphor-based theatre performance that draws heavily on the ‘*actor’s strength, agility, flexibility and imaginative power.*’ Decroux’s objective for the method was the placement of the ‘*drama inside the moving body, rather than to substitute gesture for speech as in pantomime*’. It focuses not so much on gesture, but the underlying ‘*attitude*’. This notion of attitude was not only present in antiquity in terms of gesture and oratory but also in the domain of physical sculpture. A case in point is Rodin’s work, where he considered ‘*the movement of the body is the passage from one attitude to another*’. These features of body *salience* and the ‘*art of attitude*’, introduced through the earlier work of Adams (1891) are relevant to the study of intentional action of children. These ideas of ‘*dynamic sculpture*’ and ‘*attitude*’ are returned to in the analysis and interpretation chapters.

Mime and Pantomime

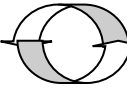
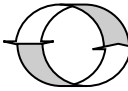
At this juncture I would like to clarify a distinction between mime and *pantomime*. Pantomime is defined as: ‘*a dramatic entertainment, originating in Roman mime, in which performers express meaning through gestures accompanied by music*’. For a discussion of pantomime see Bellinger (1927) ‘*Commedia Dell’ Arte*’. The reason for making this

distinction is that several research paradigms both in cognition neuroscience and gesture studies purport to use mime when in fact what is being considered is pantomime.

In contrast mime can be defined as: *the theatrical technique of suggesting action, character, or emotion without words, using only gesture, expression, and movement.* The act of *mimesis* is explained as the imitation or, more relevant in my thesis, the re-presentation of aspects of the sensible world, especially human actions, in literature and art. At a simple biological level this is described as mimicry; see also Donald’s extensive discussion on the role of mimesis (2007).

3.3.3 Ludic Mime and The Child Gesture Corpus

The choice of interaction paradigm that supports the Child Gesture Corpus was in part driven by the need to make physical interaction accessible to children with severe speech and motor impairment due to cerebral palsy. Such impairment often disproportionately affects the hands, facial musculature, body and posture. Thus, a gesture space is created by the presence of the gesturer (performer) and their interaction with the social other, e.g. inter-actor (researcher/therapist) or object (artefact) in any given space. In Box 3.3d I summarise four principles of mime: *Actor/participant strength; Imaginative powers; Prevalence of the trunk over other body parts, not limited to the face and hands and Drama ‘inside the moving body’* together with their key dramatic element *Effort, Pause, Hesitation, Weight, Resistance and Surprise.* Collectively these can be used to express patterns of total body connectivity e.g. developmental hyper-movements and neuromuscular shape-shifting patterns. They are used to transform ideas to make the invisible-visible. I incorporate four principles of mime together with ludic interaction paradigms to facilitate *enacted corporeal mime in gesture space.* These techniques were used when working with cerebral palsy children.

<i>Principles</i>	<i>Key Dramatic elements</i>	<i>Features</i>
<i>Actor/participant strength</i> <i>Imaginative powers</i> <i>Prevalence of the trunk over other body parts, not limited to the face and hands</i> <i>Drama ‘inside the moving body’</i>	 <i>Effort</i> <i>Pause</i> <i>Hesitation</i> <i>Weight</i> <i>Resistance</i> <i>Surprise</i>	 <i>Transformation of ideas to make visible the invisible</i>
Box 3.3 d) Developed after a feature map schematic of enacted corporeal mime in gesture space, modified after Panayi (2010).		

Cumulatively such techniques can be considered using Meyerhold’s term to *arm the imagination.* In my gesture I also compared the notion of Meyerhold’s Etudes with the Ludic

Interaction equivalent concept/prompts used for the C-i-A framework; this is presented in subsequent chapters. The interactions of corporeal forms and their relationship to a young person's imagination are discussed further in chapter 6 onwards in the context of my empirical study. Once again using Meyerhold's description, at performance level one can consider a young person at first being A1 and then becoming A2 through the process of working on their enaction.

Furthermore, I would argue that within the arenas of pedagogic, clinical and design practices we need to reconsider not only A1, A2 but also the size of our 'stages' and the role that the other actors or inter-actors play not only in performance but also in our everyday interaction with young people with or without neuro-atypical profiles. Thus the C-i-A framework combined with the G-ABAS and G-IPA can be used to annotate and interpret gestural repertoires that are consistent with both method/non-method acting and corporeal mime. I will go on to argue that such psycho-physical based practices have potential for alternative therapies.

3.3.4 Narrative Theory and Schemata

Conventional narrative theory and analysis methods are largely confined to text and are thus limited when used at discourse level alone see Young (1987 and 2002). For contemporary interpretations for narrative practice and the insights they can provide on *everyday living*, see Ricoeur (1984 and 1991) and Ochs (2002). For work that examines gesture in folklore psychology, see Gallagher and Hutto (2008). A recent review by Herman discusses the potential for narrative theory to inform studies in cognitive science. He makes the argument that such a framework can enrich our understanding of embodied experiences (Herman, 2013).

Narrative skills have been identified as being important to cognitive development, specifically in language development and as a means of making sense of our lived experiences. In neuro-typical children rudimentary story skills emerge relatively early, by 2.5 years see Sebeok and Umiker-Sebeock (1992), and develop into late childhood Bamberg (1987). In summary, neuro-typical children link events linearly before the age of 8, whilst by age 9 they have developed various perspectives on event sequence, including the integration of episodes. However, these normative developmental milestones cannot necessarily be applied to neuro-atypical children. There is little research that has examined the narrative skills of children with cerebral palsy. I know of no study that has examined the capacity of

children with severe speech and motor impairment to express their narrative abilities corporeally. For a discussion of narrative skill in children with brain injury, see Reilly et al. (1998). Bliss, McCabe and Miranda (1998) argue that assessment of language impaired children should include a measure for narrative discourse. Traditional studies often find that there is covariance between difficulties in comprehension and narrative abilities. It should be noted that the contrasting outcomes from different studies may be an artefact of the use of different assessment tools and the heterogeneity of child profiles.

For cerebral palsy, when mental age is taken into account this relationship diminishes for children aged 5-10 years see Holck (2011) and for a study involving AAC see Soto and Hartmann (2006) cited *ibid.* Holck found that on most measures the CP group performed just a little inferior to the typically developing children. This was the case for ‘both linguistically and cognitively related narrative measures’. Furthermore, comprehension difficulties may be reflected at the text rather than sentence level.

It should be noted that this narrative analysis was based on a story recall paradigm. However, Holck reiterates that memory is a cognitive ability that is thought to be tightly linked to narrative skills. Importantly, for my thesis, Holck concluded that children were delayed rather than ‘deviant’ in their profiles.

From a clinical perspective DeVeney et al.(2012) compared multi-domain and communication based strategies for assessing the developmental age of children with disabilities who have a long-term reliance on AAC. They conclude that clinicians should consider communications based approaches, include a closer examination of gesture as a more valid inference for capacity in children with limited fine and gross motor physical capabilities.

3.3.5 Corporeal Narrative, Schemata and Mimesis

My analysis of corporeal narrative uses the technique of looking for event structure explored through the construct of image schemata, see e.g. Mandler and Johnson (1977); Stein and Glen (1979); Gibbs and Colston (1995) and later in the context of embodied activity and mental imagery, Gibbs (2003); Gibbs and Berg (2002).

Conceptually, image schemata have been described as ‘*a recurrent pattern, shape...of...ongoing ordering activities*’ (Johnson, 1987, p.29). For Mandler (1996), children’s early concept formation is driven by ‘*perceptual meaning analysis*’ that supports language acquisition. However, in the context of my thesis, such studies can be classed as

ones which limit their analysis to activity restricted to image schemata that are tightly linked to either spoken or written language. As such they are not considered further in subsequent chapters of my thesis.

Finally, mention should be made of the role of gestural schemata and networks that mediate sense-making action between veridical, imaginary, social imaginary and hybrid space across time both for the individual and the social other. The term *hybrid* in my conceptual framework refers to two aspects described in Box 3.3 f) below.

- | |
|---|
| <ul style="list-style-type: none">❖ <i>presence in these interactions of artefacts that may have physical or digital embodiment or are imaginary and/or</i>❖ <i>connectivity between veridical, imaginary and social imaginary spaces</i> <p style="text-align: center;">Box 3.3 f) Explanation of Hybrid in C-in-A framework</p> |
|---|

Furthermore, our interactions unfold across microgenetic, i.e. *moment-to-moment*; ontogenetic, i.e. *across the life span*, and phylogenetic i.e. *within evolutionary* timescales. In my thesis I examine intentional action *brought forth* or as it *emerges* through gesture mediated interactions.

Once again, I prefer to make the link with the biological work of Maturana and Varela who emphasised the dynamic nature of interaction in biological systems. They state that whenever there is ‘*a history of recurrent interactions leading to the structural congruence between two (or more) systems*’ this is termed ‘*structural coupling*’ (Maturana and Varela 1992, p.75). Thus, individuals can be described as being both *constituted* by interacting subsystems and are themselves part of a larger societal-cultural system. Thus, in the Cognition-in-Action framework narrative theory is re-interpreted within the notion of *corporeal narrative*, i.e. body based expressivity of narrative concepts and events.

The analysis of gestural narrative in my thesis is informed by aspects of conventional narrative analysis. This notion of narrative corporeality is embedded in the Gesture-Action-Based-Annotation-System (G-ABAS) and G-IPA tools in terms of its descriptive feature topology. Codes that can inventory corporeal narrative abilities can be found in the appendices. Such novel tools could offer complementary insights for those working in the field of narrative theory, language impairment and/or gesture studies.

The potential of corporeal mime lies in its capacity to facilitate the expression of universal ideas and emotions through *abstraction of action*. As such, it is well matched to and the three aims of my thesis and to the performance paradigm that was used by children who contributed to the Child Gesture Corpus. Their enacted movements involve the whole body and parts of the body in relation to the ‘other’; thus they begin to provide a window on

children's imaginings. The overriding notion of corporeality is fundamental to both the theoretical underpinning and the development of the Cognition-in-Action conceptual framework. Finally, I would also argue that embodied action is part of a complex system within which narrative ability can be expressed. In the next section I return to evidence from the neuroscience to derive a *Neurology of Gesture* that supports the C-i-A framework.

3.3.6 A Derived Neurology of Gesture

Any basal ganglia and cerebellum damage, coupled with their neural connectivity, can make a significant impact on motor control and integration. In addition, such damage is likely to affect sensory and motor synchronization. Specifically, this could include aspects of *perceptual memory*, e.g. conceptual, semantic, episodic, polysensory and phyletic sensory, together with aspects of executive memory classically considered as action (both behavioural and language) and including *conceptual plans, programs, acts*. Fuster (2007) terms this type of memory '*phyletic motor memory*', i.e. that is evolutionary derived.

Such hierarchical descriptions of memory organization are re-visited and discussed in the analysis and interpretation section of my empirical study. I considered the work of Williams et al. (2012) on motor and visual egocentric transformations in children with coordination disorder and Iverson and Fagan's (2004) work that explored the nature of gesturing by blind and sighted adults.

Of specific relevance to the propositions of my thesis is the work of Peigneux et al. (2004) using fMRI studies which suggest a common substrate for '*to-be-perceived*' and '*to-be-produced*' gestural representation in limb apraxia. This research suggests a departure from conventional models and argues for a *single* memory store for gestural perception, representation and production. Once again such work both informs and supports the rationale that underpins the Cognition-in-Action framework. Figure 3.4 illustrates the synthesis of this key research to illustrate the high connectivity and diverse involvement of brain regions, providing a derived '*Neurology of Gesture*', adapted after Panayi (2001, revised 2010 and 2013). An illustrative table that summarises key research and the neural-correlates involved in motor action, imagery and features of spatial cognition together with aspects of movement and object recognition is provided in the appendices. Research on humans and primates or other species has not been differentiated.

It should be noted that relatively few studies have examined the neurology of children's spontaneous gesture. For a review of neuro-typical child gesture per se that is

predominately laboratory based, see Özyürek and Kelly (2007), who provide a comprehensive review of gesture and language as do and Alibali (2008). Capone and McGregor (2004) review gesture for clinical practice and Pennington et al. (2004 and revised 2011) for speech therapy. They both conclude that efficacy is lacking. Even fewer studies have examined the gestures of children with cerebral palsy, see appendices and chapter 2. In a review, Gallese (2007) attempts to support conventional *theory of mind* representational concepts using the MSH. He cites both neurological studies linking hand and mouth (e.g. Rizzolatti and Arbib 1998; Arbib 2005) and developmental psychology studies that link speech and gesture skills (e.g. Goldin-Meadow 1999, Iverson and Goldin-Meadow 2005). His prediction is that the ‘*opercula region of the inferior frontal gyrus should be activated by tasks involving the processing of complex, PSG-like hierarchical structures, both in the domain of action and language.*’, *ibid.* I argue that within my framework this research is relevant only insofar that it supports a supra modal mechanism, rather than theory of mind (TOM).

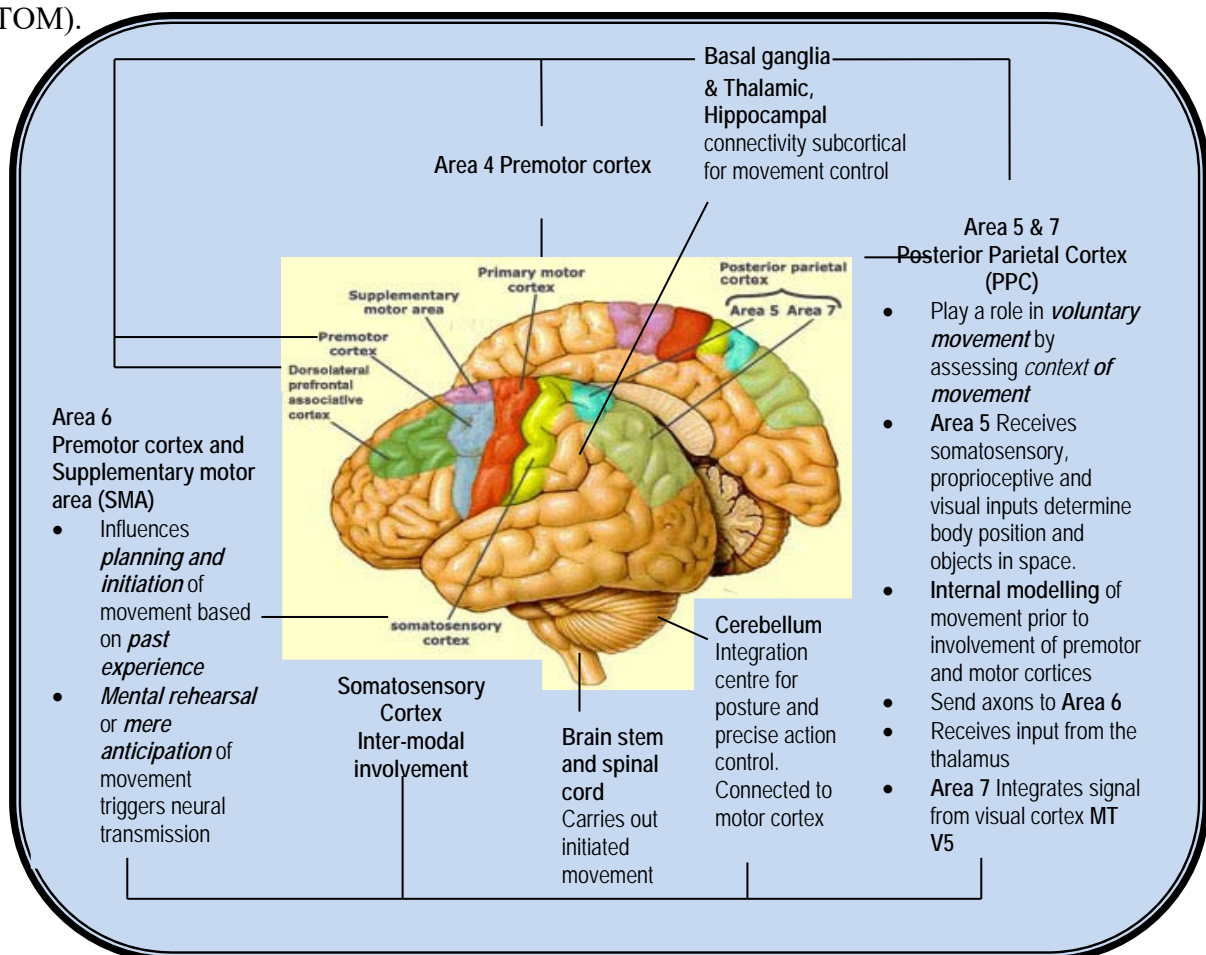


Figure 3.4 A simplified brain region map showing the diverse areas involved in motor imagery and action. These are brought together as a derived *neurology of gesture*, connectivity to the body not shown. Adapted after Panayi, (2001 revised Panayi, 2010 and 2013)). Original diagram in the centre is after Jacob Driesen.

Knauff and Ragni's (2009) and Knauff's (2013) work on spatial reasoning argue that perhaps mental imagery can impede reasoning. They identify a need to develop a '*neurally and cognitively plausible theory of human relational reasoning*'. Andric and Small (2012) provide a comprehensive review of the neurology that may underlie gesture's neural language. They surmise that '*the current results of this work do not yet give a clear understanding of gesture processing at the neural level*' *ibid* p.1.

For neuro-atypical children with severe speech and motor impairment due to CP, the basal ganglia and cerebellum are the sites of lesion. Crucially, as a collection of nuclei, they '*modify movement on a minute-to-minute basis*'.

The *movement patterns* and control of action in children with CP can be severely disrupted. Although not examining children with CP, a recent study Sauer et al. (2010) suggested gesture could be a promising diagnostic tool for persistent (language) delay. The cerebellum is involved in overall body movement co-ordination, more specifically arm movement and finger movement. Cerebral dysfunction presents as disequilibrium, muscle disturbance and motor speech disorder in the neuro-atypical children participating in this study. These features of motor dysfunction are typically seen in everyday circumstances. However, in my gestural interactions studies, movement and control are not interpreted using a deficit model of action see chapter 6 onwards for an analysis of gestural intentionality and control in young people with CP.

The observations of both kinematic and corporeal narrative features are related to the underlying mechanisms that are informed by this derived *Neurology of Gesture*. These features include five main types of cognitive and/or motor control involvement that are related to motor-cognitive function in children with Cerebral Palsy, specifically: *synchrony, motor control and memory including language and perceptual learning; working and executive memory; motor facilitation and inhibition and emotional and reinforcement learning*. These are summarised in relation to the brain based regions of involvement in Table 3.4. The C-i-A framework draws upon theories from the neurology of action for both neuro-atypical and neuro-typical movers to provide a deeper understanding of child gesture.

Cognitive And/or Motor Control Function	Neuro-correlate Areas Involvement
<i>Synchrony</i> e.g. joining of different attributes into one object (<i>sensory synchronization</i>); synchronization of different perceptual, cognitive and motor modalities	(claustrum)
<i>Motor control and memory, language control, perceptual learning skills</i>	(caudate nucleus)
<i>Working Memory, Executive memory</i>	(striatum)
<i>Motor facilitation and inhibition</i>	(globus pallidus)
<i>Emotional learning and reinforcement learning</i>	(nucleus accumbens)

Table 3.4 Five main types of cognitive and/or motor control function in relation to neuro-correlate areas involvement and cerebral palsy.

3.3.7 Summary

In this third section I provide a detailed examination of the models of corporeal action and gesture from the art of oratory from antiquity to contemporary practices in the performing arts. My focus on corporeality lies in its power to make the invisible – visible. I consider this work against contemporary and largely western writings in research and practices in performance art, theatre and narrative theory that have influenced my conceptual framework frameworks.

Biomechanics movement and mime descriptions and practices from physical theatre together with my synthesis of the art of oratory and performance in antiquity provide a conceptual and practical advantage when re-considering gesture. These practices provided support for the interaction methodologies that underlay the empirical study.

I would argue that this approach increases the robustness of construct Cognition-in-Action where *intentional action embodied as corporeal gesture*. It also validates the development of G-ABAS and G-IPA tools I use in the subsequent richer and finer grained analyses of cerebral palsy gesture. Insights gained from such analyses can be considered within a derived neurology of gesture that provides evidence for the inferred supra-modal cognitive and motor control and aspects of the C-i-A framework.

3.4 Cognition-in-Action The Framework Architecture

The Theoretical Synthesis

The Cognition-in-Action framework is presented in schematic form in Figure 3.5. It illustrates an alternative non-reductionist, non-computational feature-based conceptual architecture. It has been adapted from my earlier work where the conceptual framework was described in terms of spatial cognition see Panayi et al. (2005); Panayi and Roy (2012); Panayi (2012). A reproduction of the original version can be found in the appendices. I go onto instantiated aspects of the framework as it is used to support the exploration of child gesture in subsequent chapters. The simplified schematic illustrates the *ecology of gestural* interaction through its topology and flow. The main topological elements are described as follows: *biological unities* (self and social other) are indicated by ellipses; *artefact entity* (other including physical material object or digital artefacts) by pentagon shape. Central to the framework is the notion of the corporeal self as an *Action-ready-body* with a 1st person perspective (Intrapersonal). This internal perception, ‘*Umwelt*’, is described as endo-semiotic. Internal ‘images’ on the system are described as ‘*Innerwelt*’.

Emergent intentional action is brought forth as phenomenological ‘resonance’ phenomena. The ideas of emergent action being brought forth as phenomenological resonance have already been discussed in the context of both the work of Maturana and Varela. In C-i-A these are embodied as *Gesture Action Entities (GAE’s)* which are described as three types: Procedural (P-GAE); Semantic (S-GAE) and Episodic (E-GAE) forms of gestural knowledge expressed during interaction flow and structural coupling in societal systems. The notion of organic codes is derived from the ecological work of Barbieri, introduced in chapter 2 and discussed in this chapter. *Flow and structural coupling* of interaction is indicated by straight line two-way arrows. Non-hierarchical rhizome connectivity at the microgenetic level, with opportunities for alternative thought, action and learning between the variable forms of unities, is indicated by the two-way wavy arrow. The *nested connectivity* of the topological elements to larger subsystems within the ecology, e.g. societal, is indicated by the ribbon arrows at the far corners; *Dynamic Subsystem elements* as the central rectangle and those located to the right and left. These are described as the biosemiotic and neuro-dynamic subsystems that operate across microgenetic, ontogenetic and phylogenetic timescales. The details of the neuro-dynamic aspects of the C-i-A architecture have been briefly mentioned in chapter 2 but fall outside the scope of this thesis. They form part of the future modelling of the C-i-A framework.

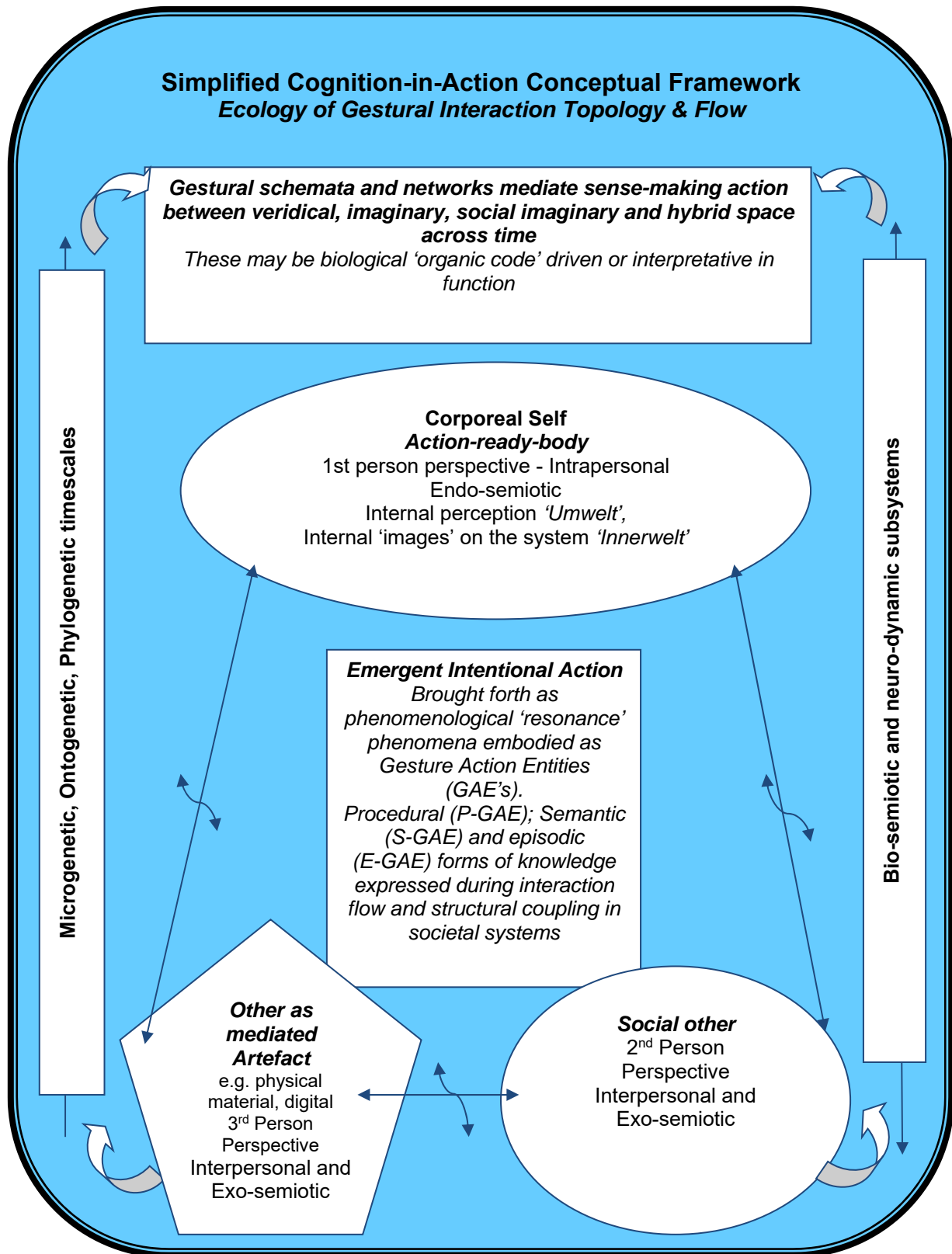


Figure 3.5 Simplified schematic Cognition-in-Action Conceptual Framework Architecture illustrating the ecology of gestural interaction through its topology and flow. Adapted after Panayi et al. (2005); Panayi and Roy (2012); Panayi (2012).

3.5 Executive Summary

In this chapter I present a critical synthesis of philosophical, biological system theory and performance practices that underpin and motivate the Cognition-in-Action framework. I discuss the merits of candidate theories and experimental paradigms that are better suited to support a deeper phenomenological understanding of child gesture. I consider the notions of intentionality and intercorporeality within the context of gesture as biological system. Corporeality is examined from both theoretical and practice perspectives. These range from antiquity to contemporary theories and practice in performance art, theatre and as narrative theory.

I outline the propositions and constructs that I use to guide a re-conceptualization of neuro-atypical child gesture. I consider emergent intentional actions of young people with severe speech and motor impairment due to cerebral palsy as expressed through their gestural repertoires. I introduce and explain the C-in-A architecture through the notion of gesture as corporeal phenomena within a biological system of complex interactions. I summarise my arguments in favour of an enactive phenomenological conceptual framework.

I revisit findings from neural-correlates methodologies which, although limited by their theoretical underpinnings, still heavily influence and limit the experimental paradigms. I argue that theoretical models that focus on the dynamics of interaction and specifically bio-semiotics and neuro-dynamics may offer new insights.

My biosemiotic and phenomenological arguments lend further support both to the rationale for the interdisciplinary approach taken in my thesis and the foci of the aims and objectives that support the development of the C-i-A framework. I return to some of these open questions in the analysis and interpretation of the child gestures and relate them to the issues of how we develop our habits and skills.

Finally, I propose that the C-in-A framework is a better candidate for re-examining human intercorporeality. Such work is illustrative of perspectives that are beginning to set the scene for a change to the boundaries with which we theorise about not only our conventional concepts of language but also of action. There is a need to re-examine the rich dynamic nature of human interactions across microgenetic, ontogenetic and phylogenetic times scales. My work offers methods, tools and theory to support such endeavours.

In the next chapter I outline the methodology that supports my empirical study of cerebral palsy gesture.

Chapter 4 Methodology

The Analyses of Cerebral Palsy Gesture

4.1 Introduction

This chapter provides the support for the second aim of my thesis *Aim 2: To develop qualitative analytical tools for the annotation and interpretation of gesture that can be applied inclusively to both neuro-atypical and neuro-typical children*. I address

Objective 3: *To outline an inclusive methodology that has the capacity to investigate neuro-atypical and neuro-typical gesture within the same paradigm*. I outline the methodology that facilitated young people's contributions to the Child Gesture Corpus. I show how it underpins the analyzed exemplars in the empirical study.

I set out my study of neuro-atypical gestures of children with cerebral palsy within the context of conventional child gesture research. In section 4.2 I outline the *Empirical Study Context*. I discuss the *challenges of gesture studies in ecological interactions* in 4.2.1. In 4.2.3 I detail the *ludic interaction paradigm*. This section ends with a summary in 4.2.3. I present the *empirical study research plan* in 4.3. I summarise the *Child Gesture Corpus* in 4.3.1 together with the *selection for the three case studies and co-participants data* in 4.3.2. In 4.3.3 I describe the *three ludic interactions protocols in the context of Condition A, B and C*. Chapter 4 ends with a *summary* in 4.4.

4.2 Child Gesture: Empirical Study Context

The methodology that established the Child Gesture Corpus has been re-considered within current best practices for qualitative empirical studies. One review was found that examines both qualitative and quantitative research to reveal the challenges and implications of research as '*situated cultural practice* see Arzubiaga et al. (2008). This review focused on informing professional practice in the domains of education and psychology where children with exceptional challenges are considered a '*cultural minority*'. Goodwin (2002), cited by Arzubiaga et al. (2008), emphasises the implication of such practice:

'where the multifaceted complexity of 'nature' is transformed into the phenomenal categories that make up the work environment of a scientific discipline.' (ibid, p315, citing Goodwin, 2002, p222)

Arzubiaga and colleagues examine contingencies that may come into play, particularly with interactions that involve fieldwork that takes place in an *ecologically valid context*. Most

significantly, this could include *'tensions between professional distance and informant's well being'*.

The term *co-participant*, rather than informant, is adopted in my thesis. It reflects the integrated relationship between the child, the therapist (where present) and the researcher and was in part influenced by participatory design practices in human computer interaction; see Ehn and Kyng (1991). The term is also consistent with the notion of *'cultural minority'* put forward by Arzubiaga. Arzubiaga and colleagues also considered the work of Bourdieu and Wacquant (1992) who work in the domain of psychology and special education. They state that in empirical studies, the focus should not be:

'the individual analyst but the social and intellectual unconscious embedded in analytical tools and operations'... where it is defined as...*collective enterprise rather than the burden of the lone academic.'* cited by Arzubiaga et al. (2008, p.324).

Earlier they provide three recommendations to guide research with cultural minorities that is ecologically valid, namely;

- ❖ *widening the analytic spotlight*
- ❖ *the socio-cultural location of the researcher and to*
- ❖ *the cultural presupposition in (research) habitual practices* (ibid, p309)

Box 4.2 a) Recommendation for situated cultural practices, after Arzubiaga et al. (2008)

These recommendations are both relevant and consistent with the theoretical framework of my thesis and my practice. The three issues of widening participation, social-cultural location of the research and the cultural presupposition have implications for both the second and third aims of this thesis. All three informed my study of child gesture phenomena.

In my thesis I derive a *situated cultural practice guideline* that is used to evaluate the empirical study (see chapter 4 and appendices). It encourages the researcher to consider the situated context, the role of the co-participants and accessibility of the design process. Borrowing a term from Cole (1997), such a guide can be used to increase the potential *integrity* for future interventions.

A more in depth discussion of the limitations and bias of research practice that lacks *'epistemic reflexivity'* (ibid, p.324) is outside the scope of this thesis. However, a discussion on the importance of this bias and its implications for the epistemology of the enactivist paradigm can be found in Havelange (2010) and Di Paolo et al. (2009).

4.2.1 Challenges of Gesture Studies in Ecological Interactions

As ecological validity increases, so do the challenges for epistemological paradigms that attempt to control for variables. This is seen at its extreme in conventional research paradigms that are both laboratory based and follow restrictive developmental psychology protocols.

I propose that *two* main challenges present themselves both for conventional and alternative child gesture studies. The first is the nature of *heterogeneous visible* form of gesture and the associated *challenges of elicitation*, notation and/or analyses. The second is the challenges of exploring the phenomenon of neuro-atypical gesture in a more *complex ecologically valid context*. As discussed in the previous chapter, the majority of child gesture studies may mention but do not focus on the detail of the social context of interaction.

Within the Cognition-in-Action framework gesture as intentional action is embodied as entities within interaction. This allows for analysis that goes beyond mere '*surface structure*' of perception, cognition or mechanical action. It enables inference of *structures of depth*. These structures arise in the first instance at the *interfaces of experience* with the *self*, *social other* and physical and imaginary artefacts within a living ecology. Only later, do they develop into more *meaningful being* through enaction. This social interaction with others can be described as a type of participatory *sense-making*, henceforth denoted by SM. In this way aspects of child cognition can be interpreted and become visible.

The second challenge informs the *empirical designs* of child gesture studies. This is particularly relevant in the case of children with *severe speech* and *motor impairment*, who have no previous significant record of gestural ability. The majority of research studies into gesture are designed to include the neuro-typical children. Where they include the neuro-atypical child, the research paradigm is predicated on a *medical or deficit model of gestural ability* and /or the notion of *gesture in the service of language*. These included studies such as those by: Reid et al. (2009); (2010); Hill and Bishop (1998). For a systematic review, see Pennington et al. (2004), updated (2011).

This is also exemplified by Cartmill et al. (2011) in a recent chapter that focuses on gesture and research into child language; citing LeBarton and Goldin-Meadow (in press):

‘Comparing gestures across children whose language trajectory is likely to be atypical (e.g., children with autism, Down syndrome, or early brain injury) is useful in understanding the nature of the child’s delay. Moreover, gesture has been shown to be an early indicator of language delay (Sauer, Levine, and Goldin-Meadow, 2010; Thal and Tobias, 1992; Iverson, Longobardi, and Caselli, 2003), raising the possibility that gesture can be used for early diagnosis and intervention when language learning goes awry’. (ibid, p.209)

As a consequence, such theoretical approaches influence methodology in terms of *parameters* used for annotation of *gestural form*, thus limiting movement notation such that it is comparable to that used in sign language research, namely: *‘(1) the shape of the hand, (2) the movement of the hand, and (3) the location of the hand in space’*. These parameters are coupled with but often limited to *four category classification coding schemes or types*; only *one* explicitly relates to movement (McNeill, 1992).

These gesture types are described by Cartmill et al. (2011) and summarised in Box 4.2.b).

- ❖ *‘Deictic* gestures direct attention toward a particular object, person, or location in the surrounding environment
- ❖ *Conventional* gestures have an agreed meaning and form within a given community and are therefore culturally shared symbols.
- ❖ *Representational (iconic and metaphorical)* gestures reference objects, actions, or relations by recreating an aspect of their referent’s shape or movement. *Iconic* gestures represent *physical objects* or *events*. *Metaphorical* gestures represent *abstract ideas* or *concepts*, e.g., moving the hands forward when talking about the future.
- ❖ *Beat* gestures are movements (typically of the hands or head) that correspond to and highlight the prosody of the accompanying speech. Beats do not have an easily discernible semantic meaning, but typically reflect the speaker’s understanding of narrative or discourse structure’ (ibid, p210)

Box 4.2 b) Conventional gesture types after Cartmill et al. (2011)

Consequently, such studies are excluded from further discussion as they do not fall within the scope of the thesis on four counts specified in Box 4.2c) below.

- ❖ *If neuro-atypical or neuro-typical gesture is not considered within a ‘widened analytic spotlight’ and/or*
- ❖ *The study is not within an appropriate ‘situated cultural minority’ context (see Arzubagi et al, 2008); and/or*
- ❖ *Gesture is not considered as an intercorporeal, intersubjective phenomenon*
- ❖ *There is insufficient capacity in existing tools to annotate aspects of Gesture-As-Action*

Box 4.2 c) Criteria for exclusion from further discussion in C-in-A framework

These challenges and the associated issues raise significant methodological and pragmatic questions for research that aims to understand the fundamental aspects of intentional action embodied in child gesture and the design of empirical studies. The challenges for the elicitation, the notation, the analyses and interpretation of child gestural phenomena still pose many open questions.

4.2.2 Ludic Interaction Paradigm

Lived experience

The ludic interaction paradigm that underpins the Child Gesture Corpus derives from the use of methods, materials and settings that approximate ‘*real-life*’ or ‘*lived experiences*’ of the co-participants, i.e. children at play, see Bronfenbrenner (1979). I specify this as a paradigm of *play* or *ludic ecologies*. It encompasses the premise that the empirical study is placed within the context of ‘*situated cultural practice*’ (Arzubiaga, 2008, p.309).

Play paradigms as research practices have a history of being used in science within the domains of education see Bruner (1990); in mathematical learning scenarios see Lave (1988) and Lave and Wegner (1991). An example of a cultural psychobiological approach is expressed in the work of Cole who argued that:

‘*behaviour sampled in one setting can be taken as characteristic of an individual’s cognitive processes in a range of other settings*’ (Cole, 1996, p.226).

The Play Stage and Cycle

Sturrock and Else (1998) describe play as *acts of creativity* that reveal *an imaginal realm or zone that is playful (ludic)*, and where those involved participate and work in this ‘*zone of emergent material and content*’ (ibid,p.5). They introduced the concept of a play cycle (Ludico) to inform the practice of the play therapist. They derive their ideas of the play cycle from a notion from the work of Winnicott (1971; 1987), who describes aspects of internalised play as a ‘*third area*’ and the ‘*potential space*’, where gestalts are internalised cited by Sturrock and Else (1998, p.11). Such internalized gestalt formations that are ‘*alive in the moment*’ become what Sturrock and Else describe as the ‘*meta-lude*’, ibid. It should be noted that in my thesis their notion of *drive* could be equated with the notion of intentionality for action. This notion of intentionality has a deeper philosophical history.

I briefly revisited both the work of Piaget and Vygotsky to examine this notion of play and creativity. Firstly, I use the notion that interactions are situated within a stage. The

Russian interpretation of this term derives from Vygotsky, i.e. as a *performance space*; not to be confused with later interpretations of stage as stages of development see Piaget (1962).

In my paradigm, these *situated stage spaces* are inhabited by the child and others including artefacts. These artefacts include both the physical and tangible, e.g. toys, artefacts, and the non-tangible, e.g. game, rules, ritual, sound and the imaginary. These *co-participants* thus provide the *boundary* or *container* for the intentional action that creates the environment for *participatory sense-making* or *meaning as action*. The role of the researcher is to both *scaffold* and *mediate* the interaction. These phenomena are used to develop insights and interpretative responses that provide a deeper understanding of child intentional action embodied in the enaction of gesture. In the development of the C-in-A framework this work is linked to notions of theatrical space and sense-making in terms of corporeal enaction (see chapter 3).

However, the task of eliciting gesture is not trivial, particularly in the case of a child with severe speech and motor impairment. As stated by Wittgenstein, '*The aspect of things that are most important for us are hidden because of their simplicity and familiarity*', cited by Sturrock and Else (1998, p.8).

Within the enactivist paradigm, ludic action is inherently an *active* and *self-structuring activity* of value to the *self* and that can be shared with the *other*, both *social others* and *artefact*. Thus, embodied action revealed in play is an ideal medium with which to empirically explore the three aims of my thesis. In Box 4.2.d) below I summarize the implications that such methods have on embodied research practices.

- ❖ *aim to derive meaning from interaction*
- ❖ *produce knowledge and representations that are a culturally and socially mediated and negotiated process* (after Arzubiaga et al. 2008, p.310) and
- ❖ *can contribute to theory-building* (ibid, p315)

Box 4.2 d) Summary of methodological implications for the C-in-A framework

4.2.3 Summary

Our understanding of human movement and of cerebral palsy movement is still lacking. I provide the rationale and theoretical grounding for using an ecologically valid ludic paradigm for eliciting child self-regulated enaction. The limitations of existing movement, communication and cognitive inventories are elaborated in the context of the need for improvements.

4.3 Empirical Study Research Plan

The empirical study plan involved three stages that are described below. The first deals with the need for adequate annotation, the second involves the re-examination of the Child Gesture Corpus and the third the iterative viewing and documentation of emergent themes.

Stage 1: *Involves identifying the need for a body-based action annotation system that is consistent with a more inclusive definition of gesture as intentional action.*

This stage was supported by reflecting on the literature presented in chapter 2 and the empirical context outlined in the first part of this chapter; specifically, the case made for the needs for a body action-based annotation system that goes beyond conventional gesture ontologies. It was clear from my earlier work and the revised literature review that existing systems are limited and could not be applied inclusively and more specifically to neuro-atypical cerebral palsy gesture.

Stage 2: *Involves the re-examination of the Child Gesture Corpus to identify the type of gestures and interaction contexts that currently challenge conventional gesture ontologies and analyses.*

This empirical study involved the re-examination of neuro-atypical gesture of children with severe speech and motor impairment due to cerebral palsy from a previously collected child gesture corpus. The main challenges here are two-fold: a) the limitation of conventional gesture annotation systems to be inclusive and b) how to annotate levels of complex gestural interaction. The three case study exemplars were chosen based on these initial criteria.

Stage 3: *Involves the iterative viewing and documentation of emergent themes that arise from both the G-ABAS annotation and the adapted G-IPA Interpretative Phenomenological Analyses.*

These gesture exemplars are examined by qualitative descriptive feature-based analyses using the G-ABAS tool together with an adapted Interpretative Phenomenological Analysis (IPA). The Interpretative Phenomenological Analysis (IPA) was adapted from text analysis for gesture (G-IPA). Figure 4.1 illustrates the body-based action annotation system for corporeal gesture (G-ABAS). It gives an overview of the two main themes (phases); each has five subordinate feature groups which are further subdivided to facilitate the annotation of in the region of 260 gesture features. This is later referred to together with visualizations of the gesture sphere and descriptors as a ‘*body map*’. The progressive viewing of the original corpus and the selected gesture exemplars of both neuro-typical and neuro-atypical gestures result in documenting emergent themes. Only neuro-atypical exemplars are presented in my thesis. I created meta-data annotation that I used to explore the research questions. The

findings were used to instantiate aspects of the Cognition-in-Action framework and provide new insights. These tools are detailed in chapter 5. The analyses are presented from chapter 6 onwards. Finally, the symbolic annotations I developed that may be useful to expert gesture researchers wanting to transfer their annotations to compatible computer-based annotation systems for more quantitative analyses can be found in the appendices.

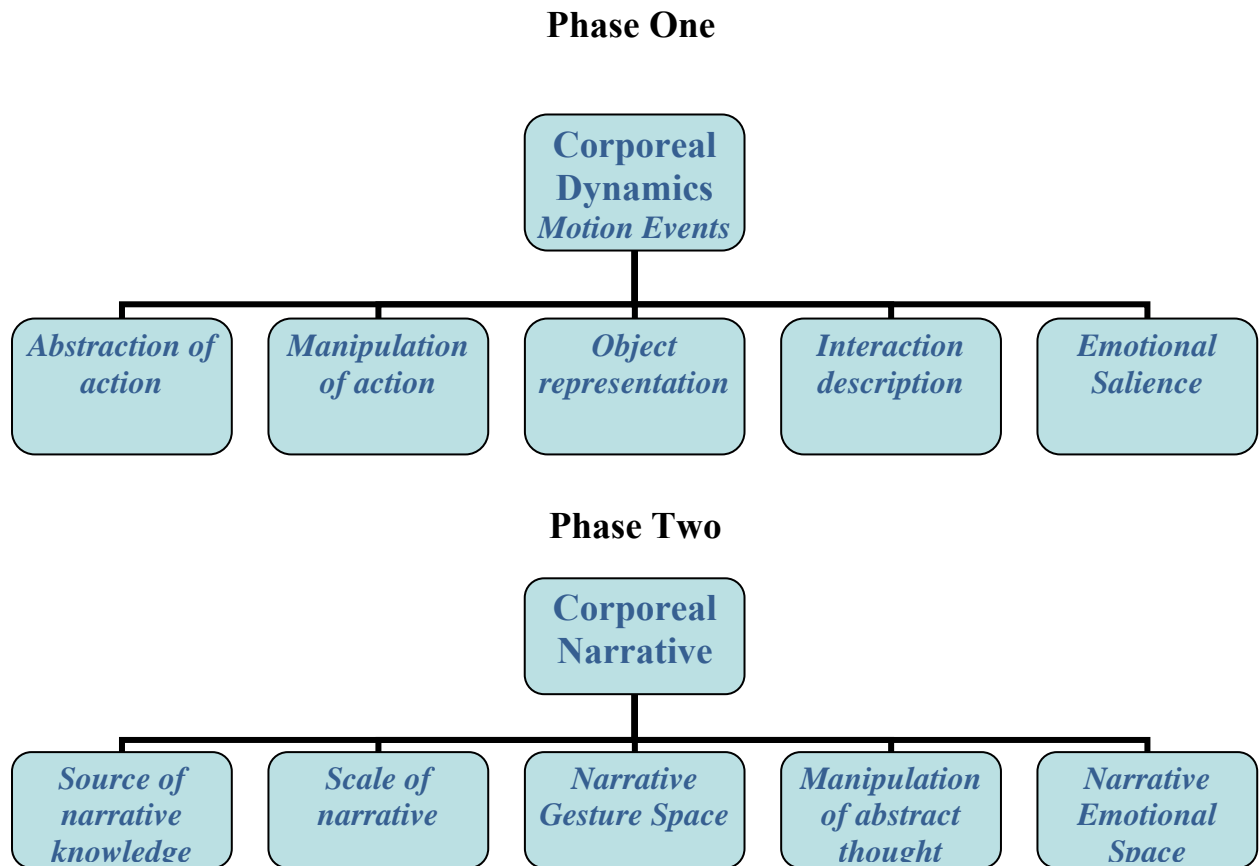


Figure 4.1 (G-ABAS) Overview of the two main themes (phases); each has five subordinate feature groups which are further subdivided to facilitate the annotation of in the region of 260 gesture features.

4.3.1 Child Gesture Corpus

Summary Description

The Child Gesture Corpus comprises video material from both neuro-atypical children with severe speech and motor impairment due to cerebral palsy, aged 5-17.9 years, and neuro-typical children aged 6-12 years. The corpus contains video material of ludic interaction primarily related to several different participatory design sessions for the development of future technology. These are embedded in ecologically valid environments. The corpus currently contains in the region of 85 hours of video. The selection criteria for neuro-atypical co-participants in the original study that established the corpus were restricted to children

with severe speech and motor impairment due to cerebral palsy and are reported elsewhere (Roy, 1996).

These included two principal criteria which are described in Box 4.3 a) below.

- ❖ *Need: severely speech and motor impaired due to cerebral palsy, with difficulty targeting switches commonly used for human-machine interaction*
- ❖ *Cognitive ability: sufficient receptive language skill and cognitive ability to interact in the proposed interaction and data collection sessions.*

Box 4.3 a) Principal criteria for selection edited after Roy, 1996, p.34

For neuro-atypical children recommendations were sought from teacher, therapist and/or the child's clinicians. Neuro-typical children were recruited as self-selected samples from local networks including schools and parent organisations.

Clinically the neuro-atypical children whose exemplars are presented in my thesis could be described using the CFCS system as being at Level IV. This is described as being an: *inconsistent sender and/or receiver with familiar partners* (even when using AAC supported devices). They were all wheelchair users; none were identified as having significant gesture repertoires. They all used some form of alternative communications due to difficulties in speech production due to dysarthria. Some were learning to use electronic communicators at the time they made their contributions. All the co-participants were dependent on their carers for their every day needs, e.g. feeding and healthcare. These initial contributors were all based in special schools in the USA.

Validation of Design, Protocols, Ethics and Reliability

The validation of the design was achieved through the use of pilot observations to establish areas of interest for the development of gestural interactions. Warm-up sessions were incorporated to ensure continued understanding. The rationale for the use of ludic formats has been discussed. With regard to ethics, all co-participating children and their legal guardian or carers provided consent to participate in any study that contributed to the child gesture corpus. All co-participants are aware of the general aims of any research project, together with the purpose and research use of the Child Gesture Corpus.

Ethics permission was granted by the associated academic, clinical institutions and research groups in the UK, USA and EU, in line with their individual regulations. Selection for co-participation and contribution to the Child Gesture Corpus associated with these research and arts projects was dependent on the active agreement of the children and their legal guardians. Acknowledgement to child, parents/carer, staff and collaborators can be

found in the introduction to the thesis and related published research and reports are referenced in the bibliography.

Access to the video material from the original corpus and subsequent contributions was agreed with the co-participants. Due to the nature of the material, access is restricted and is held by the participating school on behalf of the co-participants, individual parents on behalf of their children and the principal researchers in each associated project.

Later Additions to Corpus

This corpus was later added to, to include gesture repertoires from both neuro-typical and neuro-atypical children in different ecologically valid contexts, e.g. ludic games, technology design session, interactive technology. These children were based in the UK, Belgium, Denmark, Italy, The Netherlands and Greece. A summary table is provided in the appendices. Selection criteria for neuro-typical children were that they should fall within the child-adolescent age range of the original corpus and in terms of need and cognitive ability they should meet both criteria described in Box 4.3 b).

- ❖ *Need: should have no physical challenge*
- ❖ *Cognitive ability: should have sufficient receptive language skill and cognitive ability to interact in the proposed interaction and data collection sessions*

Box 4.3 b) Selection for neuro-typical co-participants, Panayi (1998)

However, only exemplars from neuro-atypical children with severe speech and motor impairment from the initial contributors are presented in this thesis.

4.3.2 Three Case Studies Selection and Data for Co-participants

Cerebral Palsy

The design for the interaction studies was driven primarily by the need to have a paradigm that was accessible to co-participating children with severely compromised speech and motor impairment due to cerebral palsy. Cerebral palsy (CP) is a non-progressive developmental neuro-motor disorder resulting from abnormality in the developing brain during the neonatal stages, at birth or soon after birth. Postural and motor impairments vary according to the location of the brain lesion site. Affected areas of the brain include the:

‘cerebellum and basal ganglia and their connectivity; both areas are implicated in movement integration. The resulting palsy is descriptive of the resultant movement disorders due to damage to the motor control centres of the brain.’ Bax et al. (2005)

For a discussion of clinical and MRI correlates of cerebral palsy see Bax et al. (2006). Cerebral palsy children who contributed to the child gesture corpus were diagnosed as

quadriplegic, reliant on wheelchairs for mobility and carers to assist with their everyday living needs.

No significant dynamic gesture repertoires were previously documented. Movement profiles are often described as '*writhing, chaotic and uncontrolled*'. Typically, these children are unable to use standard technology interfaces. Speech is severely impaired and often unintelligible (dysarthric). External aids such as synthetic voice output computers or eye gaze alphabet boards are used for communication. This type of communication is often referred to as Augmentative and Alternative Communication (AAC). Similarly, access to conventional play opportunities may be severely compromised and/or may need adaptation; for a review see Bartlett et al. (2010). However, there is no mention of gesture, mime, physical theatre or other enactment interaction paradigm typically being used for rehabilitation intervention or pedagogy in the case of these neuro-atypical children.

Selection Convenient, Pragmatic and Purposive Sample

Within a qualitative research paradigm my small sample was selected based on *convenient* and *pragmatic* considerations. It reflects two significant ethical and philosophical groundings of the qualitative research paradigms; firstly, the *stakeholders* are children whose quality of life is particularly affected by their interaction with the world; secondly, they are illustrative of *extreme case* criteria. They are children with severe speech and motor impairment due to cerebral palsy. Such cases are often of interest to researchers because they '*represent the purest or most clear-cut instance of a phenomenon*' (Palys, 2008, p.697). Palys goes on to clarify purposive sampling. This guidance is consistent with the methodological approach I adopt in my thesis; he states;

'purposive sampling signifies that you see sampling as a series of strategic choices about with whom, where and how to do your research. Two things are implicit in that statement. First is the way that your sample has to be tied to your objectives. Second is an implication that follows from the first, i.e., that there is no one "best" sampling strategy because which is "best" will depend on the context in which you are working and the nature of your research objective(s).'' (Palys, 2008, p.697)

In my thesis the case study methodology is not necessarily one used for generalization. It focuses on understanding the individual gesture in its complexity. The bounded system in all cases is that of enacted gestures in ludic interaction. The philosophical and methodological underpinnings of the research illustrate how *children and researchers as co-participants* meet the *expert* sampling criterion. Finally, the selection criteria also meet the theory-guided sampling type used for qualitative studies, as I use the findings iteratively to inform the

C-in-A framework. Three principles guided the choice of selection criteria for the case studies, described in terms of the phenomena and shown in Box 4.3 c) below.

- ❖ *Criterion 1. The selection of neuro-atypical child gestures is a robust phenomenon.*
- ❖ *Criterion 2. Potentially the gesture exemplars could be used to constructing the validity of gestural ability of both neuro-atypical and neuro-typical children*
- ❖ *Criterion 3. The analysis and interpretation of the phenomena can potentially offer new insights in to the nature of gestural abilities of both neuro-atypical and neuro-typical children within the context of the conceptual framework.*

Box 4.3 c) Selection criteria

Criterion 1 was supported by previous work see Roy (1996). All the neuro-atypical child gesture repertoires from Condition A presented in my thesis, were manually segmented and annotated. However the manual annotation was limited to a three-part *simple movement classification* system for gesture. Duration of the gesture and the body part involved and whether the gesture was a *static pose involving a single movement* or a *periodic movement* were noted. Details of the computer gesture recognition of a subset of gesture for selected children can be found in Roy et al. (1994) and Roy (1996).

The children selected in my case studies were typical of those who contributed to the initial corpus of neuro-atypical gesture. Three case studies were selected based on the criteria that each co-participant could be responsive in the ludic interaction as described in Box 4.3d).

- ❖ *Engage and motivate a wide age range of children to express themselves physically*
- ❖ *Be inclusive, i.e. can be used for both neuro-atypical and neuro-typical children*
- ❖ *Be implemented within limited resources.e.g.in school, therapy or technology design session*
- ❖ *Be easily accessible to practitioners with different levels of expertise across interdisciplinary domains*
- ❖ *Have the capacity for progressive development ,i.e. tailored to the individual profile*
- ❖ *Be combined with other non-technology and technology body-based measurement systems*

Box 4.3 d) Advantages for co-participants in relation to ludic interactions scenarios

Illustrative gesture exemplars and analysis are presented for these three selected case studies, Case Study 1, Case Study 2 and Case Study 3 summarised in Table 4.1.

The selection and sampling process, data structure, sampling type and validation are considered further in chapter 5 onwards together with reliability of gesture annotation. Briefly, in my empirical study inter-coder reliability of gesture experts in 10% of the annotations was consistently over 90%. Any disagreement was discussed to consensus. If agreement was inconclusive the item was discounted in the analysis. This level of reliability is comparable with other qualitative research, including gesture studies. A Cohen's kappa

calculation together with a discussion on issues that relate to increasing gesture analysis reliability can be found in chapter 6 onwards and appendices.

Profile Data for Co-participants

Case Study 1 From Condition A I present exemplars from the repertoire of a neuro-atypical male adolescent, aged 16.9 years. In Case Study 2 Condition B, exemplars are contributed from a neuro-atypical male adolescent, aged 17.9 years and for Case Study 3 Condition C, from a neuro-atypical female aged 10.7 years. All children presented in the three case studies had experience of condition A. Each young co-participant is briefly identified by initial ability, gender and age at time of contributing to child gesture corpus together with co-participant identifier code, see Table 4.1.

Ludic Interaction	Case Study	Gender	Age	Co-participant code
Condition A <i>Adapted Charade Game</i>	1	M	16.9	NAT-CP 9
Condition B <i>Narrative Co-constructed</i>	2	M	17.9	NAT-CP 5
Condition C <i>Manipulation of Artefact</i>	3	F	10.7	NAT-CP 7

Table 4.1 Summary of interaction protocols and selected case studies for each ludic interaction. Key: Co-participant child identifier codes, NAT: Neuro-atypical. See also Tables 4.2-4.4

Profiles Cognition, Communication and Mobility

Summary profiles for the co-participating young people are presented in the following series of tables: Table 4.2 gives details of diagnosis and quality of volitional movement and associated information; Table 4.3 shows the methods of communication at the time the young people contributed to the original corpus. Table 4.4 shows supplementary details in terms of mobility access and out-of-chair mobility extracted from original data held in the corpus.

Co-participant Child Identifier code	Diagnosis	Age year, month/ Gender/ ^a Cognitive level	ATNR/ STNR ^b	MVPT Vision/ visual Tracking problem	Reported quality of volitional (<i>active</i>) movement
NAT-CP 9	Spastic-Athetoid quadriplegia (CP)	16,9 M ^a 11,0 (17,4)	Yes	23/36 on the MVPT ^c perceptual age level of (5-10)	“active range of motion limited to flailing type movements of upper and lower extremities” “marked fluctuations in muscle tone with choreoathetotic movements” “unable to functionally use hands secondary to Athetoid movements” “ <i>uses switches with head and legs</i> ” “ <i>dependent for all areas of self care</i> ”
NAT-CP 5	Athetoid quadriplegia (CP)	17,9 M ^a 10,5 (16,10)	Yes		“demonstrates unintegrated primitive reflex, observable in his voluntary and involuntary movements” “ <i>movements also exhibit the fluctuation of extension and flexor patterns characteristic of athetosis</i> ” “ <i>midline orientation, mid-range cortical and distal control are poor</i> ” “ <i>exhibits proximal stability</i> ” “ <i>unable to assume any sitting position independently</i> ” “ <i>unable to assume or maintain standing with less than maximal support</i> ” “ <i>is able to assist in a stand –pivot transfer</i> ”
NAT- CP7	Athetoid quadriplegia (CP)	10,7 F ^a 3,7 (9,8)	Yes	Yes	“isolated finger movement” “active range of motion within functional limits although often exhibits excessive range of motion” “ <i>presents with great fluctuations in her muscle tone</i> ” “ <i>with excitement or attempts to move her muscle tone increases dramatically with generally strong extension of her trunk and extremes of range in her extremities</i> ” “ <i>requires maximal assistance at her trunk secondary to scoliosis which increases with effort</i> ”, wears body jacket “ <i>able to assist with sit to stand transfer with support</i> ”

Table 4.2 Personal and Diagnostic data. Three neuro-atypical children with cerebral palsy (NAT-CP) selected for inclusion in the empirical study of my thesis. From the left, co-participant code; diagnosis; age at initial participation; gender; cognitive level as indicated by Peabody picture vocabulary test (PPVT-R form L) year, month. Age at testing indicated in parenthesis; Asymmetric tonic reflex (ATNR)/Symmetric tonic reflex; MVPT, Motor-Free Visual Perception Test, i.e. no motor involvement need to make a response and involuntary primitive reflexes. Details added by Panayi (1998) from reported quality of movement are shown in *italics*. Extracts from corpus provided with kind permission (Roy, 1996).

Co-participant Child Identifier code	Electronic Input method	Selection strategy	Electronic AAC system/ *Non- Electronic	Unaided primary method of communication	Other details
NAT-CP 9	Right knee switch	Row-column scanning	VOCA Light talker *Past use of E-tran	<i>“ non-verbal due to severe dysarthria”</i> <i>“25% intelligibility with dysarthric speech and familiar communicator in known context at one-two word level”</i> Eye-gaze, some head/facial gesture	-
NAT-CP 5	Single side mounted head switch. Being evaluated for multiple switches	Row-column scanning	VOCA Light Talker English orthographic board with adapted Fitzgerald key 600+ items	<i>Severe dysarthric speech</i> <i>Eye gaze – “up” for “yes”, look “down” for “no”, with head shaking, eye gaze pointing to indicate objects and locations e.g. to large numbers in board perimeter</i>	“ constant poorly graded gross movements characteristic of athetosis are hard on equipment”
NAT-CP7	Pad switch with left hand	Linear scanning 32 location	VOCA Light talker (under evaluation)	No documentation of any speech ability, <i>non-word vocalization</i> “restricts reliable use of eye gaze, switch scanning, deictic gestures” Oral-facial gestures, consistently signs an “OK” sign approximation “thumb and index finger together”. Direct pointing using left index finger	“direct selection using hand-held optical indicator was problematic due to increased Athetoid movements as selections were attempted”

Table 4.3 Methods of Communication Data. Three neuro-atypical children with cerebral palsy (NAT-CP) selected for inclusion in the empirical study of my thesis. Shows the existing methods of expressive communication, extracted from original corpus details with kind permission, Roy (1996). From the left, co-participant code; electronic input method; selection strategy; electronic AAC system; non- electronic system; unaided primary method of communication including any deictic arm/hand gestures/other gestures. Supplementary details added by Panayi (1998) from the corpus record are shown in *italics*.

Co-participant Child Identifier code	Mobility	Mobility Access Methods	Out-of-Chair Mobility
NAT-CP 9	Powered wheelchair	Three head-switches, 1 knee, 1 elbow switch	<i>“ some independent floor mobility by scooting with head and lower extremities in marked extension” “ rolls from prone to supine, not supine to prone” “can sit unsupported briefly, but usually requires full support of laterals, seat belt and foot straps.”</i>
NAT-CP 5	Powered wheelchair	Three head-switches, 1 knee, 1 elbow switch	<i>“ preferred out-of-chair mobility is rolling” “ unable to assume any sitting position independently”</i>
NAT- CP7	Manual wheelchair Being evaluated for powered mobility (joystick)	Three pad switches with left upper extremity	<i>“greatest independent mobility is noted in supine...scoots for short distances using neck and trunk hyperextension and pushing with legs”</i>

Table 4.4 Means of Mobility Data. Co-participant code identifier shown for three neuro-atypical children with cerebral palsy selected for inclusion in the empirical study of this thesis. Shows the mobility and powered mobility access methods, includes extract from original corpus details, kind permission, Roy (1996). Supplementary details added by Panayi (1998) from the corpus record for *out-of-chair* mobility are shown in italics.

4.3.3 Three Ludic Interactions Protocols

Background

Critically, the interaction design supports motor-cognitive frameworks within the Cognition in Action construct. The paradigm brings together motoric aspects of intentionality with cognitive engagement. This is achieved by adapting corporeal mime and physical theatre practice and narrative interaction. The empirical study plan was both iterative and flexible. It was developed responsively to the latent gestural abilities of children with severe speech and motor impairment.

Corporeal Dynamics in Movement

This paradigm can also be described as a non-invasive movement (enaction) technique that encourages the *bringing-forth* of spontaneous or near spontaneous intentional action from the child. For the purpose of the empirical study it provides an opportunity to *make the invisible visible*. Such interactions provide a small window on the imaginary world of children.

The potential of an enactive paradigm is that it can be used as part of early intervention strategy. This work is relevant to the third aim of my thesis. Such an *activity-*

based intervention could encourage motor activity that could potentially be transferred to everyday activity and possibly functional action. Importantly, Damiano (2007 and 2007a) in a re-consideration of the state-of-the-science in *neuro-rehabilitation*, and specifically in the context of cerebral palsy, suggests that:

'we are not even close to approaching the human limits for physical and neural recovery in many disorders. A growing body of scientific data, much of which was published in the last few years since the turn of the millennium, strongly suggests that activity-based strategies, which are within the purview of physical therapy, are one of the keys to unlocking the now far brighter potential for functional recovery,' (Damiano, 2007, p.1539)

In this study, games were devised to elicit gestures from both neuro-atypical and neuro-typical children. The design was informed both by ludic paradigms, narrative theory and practices in the design of human computer interaction.

Corporeal Narrative in Movement

Where verbal scripts were used, they were informed by the work of Labov and Waletzky (1967), i.e. as a referential core of *personal narratives*. They also included the notion of *canonical events*, after Bruner (1990). He describes narrative as mediating:

'between the canonical world of culture and the more idiosyncratic world of beliefs, desires, and hopes. It renders the exceptional comprehensible and keeps the uncanny at bay—save as the uncanny is needed as a trope. It reiterates the norms of the society without being didactic. And . . . it provides a basis for rhetoric without confrontation. It can even teach, conserve memory, or alter the past.' (Bruner, 1990, p.52)

Narratives have the advantage of imposing a presentation sequence for introducing several narrative features. These can include: *character, narrative events, actions, everyday and novel objects (artefacts)*. The role of schemata in intentional action was introduced in chapter 2. In the context of the role of schemata Bartlett (1932) and (1920) developed both experimental protocols using fables and a theory of remembering; specifically he proposes the word 'schemata', whilst not being totally satisfied by its use - '*I strongly dislike the term [201] 'schema'*' (ibid)- he describes it as being built of:

'common materials, the images and words that mark some of their salient features are in constant, but explicable, change. They, too, are a device made possible by the appearance, or discovery, of consciousness, and without them no genuine long-distance remembering would be possible.' (Bartlett, 1932)

However, he does suggest that perhaps a better description could be '*active, developing patterns*'. I adopt and develop the latter terminology in my thesis. He describes the bases of schemata in terms of '*perceptual alterations in position*' that affect a '*postural model of*

ourselves which constantly changes' (Bartlett, 1920, pp.605-6). Although he locates this activity within the cortex, his descriptions could be reconsidered within a contemporary theoretical framework as acknowledging not only the role of perception and corporeal interaction but also the *plastic* dynamic nature of memory (equated with aspects of schemata).

Bartlett goes on to argue for the critical role and relationship of remembering to imagining where: *'bringing remembering into line with imagining, an expression of the same activities; it has very different implications in regard to forgetting from those of the ordinary trace view; it gives to consciousness a definite function other than the mere fact of being aware'* (Bartlett, 1932).

Later work by Mandler (1988, 1992 and 1996) developed ideas on conceptual primitives as representational systems. She then explored the foundation of conceptual thought (2004) and has latterly considered the spatial nature of the conceptual system (2010).

Advantages of Enactive Paradigms

The design and analysis presented in my thesis highlights how such interactions would potentially be accessible to all children irrespective of their motoric challenges. Corporeal principles are embedded within all the ludic interaction conditions. The stimuli or probe design can accommodate both real and imaginary people and natural, man-made and imaginary artefacts. The imaginary objects afforded actions, including those that relate to *varying grasp and size*, e.g. power grip, precision grip, and smaller manipulative movements, described as types of *micro-gestures*.

The G-ABAS allows for these and *reaching strategies* in e.g. egocentric and/or allocentric space, to be documented. In the case of neuro-atypical children, the nature of grasp and reaching action may require modified strategies, due to limitations in typical grasp and reaching. This is discussed further in the ensuing chapters.

In terms of narrative analysis my proposed system elaborates the notion to one of *corporeal narrative*. This extends conventional narrative theory which deals with oral or written narrative. Thus, a corporeal mime and physical theatre paradigm, adapted from the work of Decroux (1982) and Boal (1995) respectively, are well-matched practices for the interaction design adopted in my empirical study. Furthermore, they support the theoretical underpinning of the Cognition-in-Action framework which is based on the notion of *gestural enaction as performance*.

4.3.4 Condition A, B and C

Charades, Co-Constructed Narratives and Manipulation of Artefacts

Meta-data sets can be created from the corpus. In my thesis I illustrate this through the selection and analysis of three case studies. The three case studies were selected from three different ludic interactions. The protocols for the collection of data included the children being invited to a warm-up session to ensure that they understood the concepts of drama/make believe, mime/gesture and the requirements of the ludic interactions.

The case studies are presented with exemplars from three interaction scenarios described in Box 4.3.e) below.

- ❖ **Condition A-** An adapted charade game using a verbal prompt
- ❖ **Condition B-** A story game involving re-enacting of narratives in response to an oral narration, i.e. *co-constructed narrative* and
- ❖ **Condition C-** Manipulation of veridical, i.e. physically present objects (originally elicited during a technology interface design sessions).

Box 4.3 e) Three Interaction Scenarios

Using conventional simplistic empirical descriptions, the protocols provide stimuli or experimental probes in different sensory domains. The auditory conditions use speech alone, e.g. charade game and co-constructed narrative. The manipulation of physical artefacts involves the audio-visual-haptic domain. This empirical design ensured near-spontaneous production of gestures that were not imitative, but *enacted as performance*. It allowed for *movement improvisation* opportunities, rarely offered to children with severe speech and motor impairment. Further details of the interaction protocols, i.e. stimuli, duration, recording, location of the co-participants and management of the interaction are provided in the appendices. Aspects of these studies and selected exemplars have been reported elsewhere see Panayi (1998); Panayi (2000); Panayi et al. (2000) and Panayi (2012).

4.3.4.1 Condition A Charade

Background

Condition A is described as an adapted charade or mime game. From a biomechanical perspective corporeal mime can be described as focusing on harnessing aspects of the *muscular-skeletal* system for enaction. The long term gains for such a system are as yet unknown. However, corporeal mime is known to increase *muscle mass* and develop *range of mobility* and *strength*. Such corporeal mime approaches provide new opportunities to explore several aspects of movement. Performance mime training includes the development of aspects of *precision, changes of planes and levels, opposition, fixed point focus, precarious balance, dynamic immobility* and *torsion* see Decroux (1985, p.60). All contributors to the Child Gesture Corpus experience the charade condition first. This provides both child and therapist with a sense of the child's gestural capacity and can provide a starting point for developing further individually tailored interaction scenarios.

Protocol Summary Condition A involved the verbal presentation of the charade prompt, e.g. 'pretend to play the piano', sip soda, be a witch. The complete set comprised 141 items, e.g. feelings, abstract concepts; these are summarised in Table 4.5 a) and b). The child played the role of the game-player and the therapist, where present, a supportive team member. The child could choose to play or move on or ask their team player for a clue. This option was rarely taken up by the child. The child could choose to end the session or take breaks. The researcher played the role of the game-show host. Where appropriate the game-show host included the use of puppets or props to maintain engagement and/or add humour to the games, e.g. use of a byrd™ puppet, soft toys, wearing of Groucho Marx glasses. Further details of the interaction protocols are provided in the appendices. The session was sustained for 30-40 minutes. Table 4.5 summarises the 18 notional categories on which the 141 items are randomly selected and presented. These include what are conventionally termed transitive and intransitive gestures. The interaction is schematically illustrated in Figure 4.2. The dotted wavy line is illustrative of corporeal enaction, i.e. a change in body performance with associated corporeal dynamic features by co-participating child, seated on the right. This is in response to a word or phrase initiated by game-show host, seated on the left. Therapist not shown, sessions are videotaped.

Condition A Adapted Charade Game

Co-participating child is presented with a word or phrase by the researcher (game-show host) e.g. *pretend to play the violin*, *pretend to be a witch*.

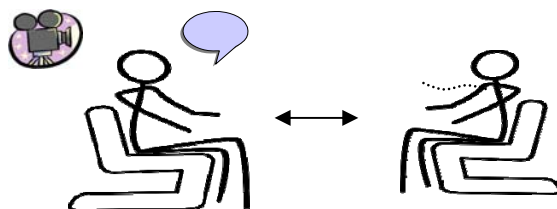


Figure 4.2. Condition A the Charade Game interaction schematically illustrated.

18 Notional Gesture Categories Shown with examples.		Child Gesture Corpus Bodily Enaction Repertoires Stylized
<p>Actions: <i>Crawl, pull, tear</i></p> <p>Animals: <i>lion, elephant, snake</i></p> <p>Communications: <i>hello, good-bye, wave</i></p> <p>Descriptions: <i>tall, short, large</i></p> <p>Events: <i>earthquake, explosion</i></p> <p>Fantasy Characters: <i>dragon, witch</i></p> <p>Feelings: <i>sad, happy, disgusted</i></p> <p>Eating Food: <i>eat hamburger, sip soda</i></p> <p>Movement: <i>faster, slower, delicately</i></p>	<p>Musical instruments: <i>piano, drums, violin</i></p> <p>Objects: <i>cup, necklace, binoculars</i></p> <p>Outlines/Shapes: <i>square, triangle, stripes</i></p> <p>People: <i>brother, mum, you, stranger, friend</i></p> <p>Senses: <i>hot, cold, bright</i></p> <p>Sport: <i>swimming, fishing</i></p> <p>Travel: <i>train, helicopter</i></p> <p>Weather: <i>rain, snow</i></p> <p>Miscellaneous: <i>steal, drink poison, smoke</i></p>	

Table 4.5 a) Condition A Charade Game Verbal prompts 141 items across 18 notional categories schematically illustrated to the right. Adapted, with permission Dr. D.M Roy, from Table 4.4 (Roy, 1996, p.39), 'Gestural Human-Machine Interaction, using Neural Networks for People with Severe Speech and Motor Impairment due to Cerebral Palsy', PhD. Thesis, City University, London UK. The stylized version is used to explain the concept of gesture to co-participating young people.

Gesture No	Illustrative presentation sequence of verbal (speech prompt) quasi-random shuffled cards				
1	Yes	56	Hot	111	Wash Face
2	Good-bye	57	Smell	112	Dig hole
3	Don't know	58	Smooth	113	Crawl
4	Hello	59	Cold	114	Pull rope
5	No	60	Soft	115	Asleep
6	Stop	61	Ten pin bowling	116	Take a picture
7	Kiss	62	Cards	117	Handshake
8	Mickey Mouse	63	Fishing	118	Dance
9	Waiter	64	How Big? (fish)	119	Sticky
10	Giant	65	Canoe	120	Knit
11	Open Box	66	Swimming (crawl)	121	Cut Throat
12	Cowboy/horse ride	67	Grand slam	122	Sewing
13	Lasso	68	Make a basket	123	Whistle
14	Baby	69	Tennis	124	Stir
15	Bathroom	70	Throw dice	125	Cup
16	Money	71	Football/ touchdown	126	Type (Typewriter)
17	Necklace	72	Rain	127	Climb
18	Umbrella	73	Cold (it's)	128	Tear up
19	Binoculars	74	Hot (it's)	129	Throw
20	Trumpet	75	Sunny	130	Knock
21	Violin	76	Rainbow	131	Saw
22	Guitar	77	Snowflake	132	Bring! Bring! (Phone)
23	Piano	78	Lion	133	Catch
24	Saxophone	79	Pig	134	Hammer
25	Flute	80	Caterpillar	135	Push
26	Drum	81	Butterfly	136	Shave
27	Explosion	82	Alligator	137	Ironing
28	Earthquake	83	Elephant	138	Dragon
29	Pizza	84	Snake	139	Witch
30	Ice cream	85	Fish	140	Ghost
31	Yuk	86	Bird	141	Monster
32	Sip soda	87	Spider		
33	Eat hamburger	88	Beard		
34	Yummy	89	Poison		
35	Triangle	90	Naughty		
36	Mountain	91	Large		
37	Square	92	Tall		
38	Circle	93	Short		
39	Stripes	94	Milking a Cow		
40	Hungry	95	Mosquito		
41	Excited	96	Steal		
42	Tired	97	Waves (sea)		
43	Hug	98	Think		
44	Sad	99	Toss a Pancake		
45	Love	100	Shampoo		
46	Ouch !	101	Cigar		
47	Angry	102	Balloons		
48	Fast car (racing)	103	Kite		
49	Train/Pull Whistle	104	Patter cake		
50	Helicopter	105	Salute		
51	Car (slow)	106	Press door bell		
52	Airplane	107	Open Door		
53	Listen	108	Close Door		
54	Captured/(surrender)	109	Jump		
55	Bright Light	110	Itch		

Table 4.5 b) Illustrative presentation sequence of verbal (speech prompt) quasi-random shuffled cards

4.3.4.2 Condition B Co-constructed Narrative

In this second interaction condition the child/adolescent produced gestures to illustrate a story narrated by the co-participating researcher. The narrations used in this interaction condition were topical, i.e. related to the young person's interest and could include novel or rare events to both engage the young person and to encourage creative gestural interaction. The term *co-constructed narrative* implies joint activity between the co-participants in the creation of a culturally situated social interaction. The *form* of the interaction being created and interpreted in this instance is *corporeal narrative*, expressed through bodily gesture. The interaction is schematically illustrated in Figure 4.3. Table 4.6 summarised the key features of verbal principal verbal descriptor of target enaction embedded in the narrated story script for this case study. The session was sustained for 30-40 minutes. Further details of the interaction protocols are provided in the appendices. The dotted wavy line is illustrative of corporeal enaction, i.e. a change in body performance by co-participating child, seated on the right. Sequences of response are made interactively to the spoken narrative, indicated by the double speech bubbles. This is performed by the story partner, i.e. the researcher, seated on the left. Therapist is not shown, sessions are videotaped

Condition B
Story Games
Child provides the *gestural stream* to a *spoken narrative stream* from their co-participant, i.e. an example of Co-Constructed Narrative

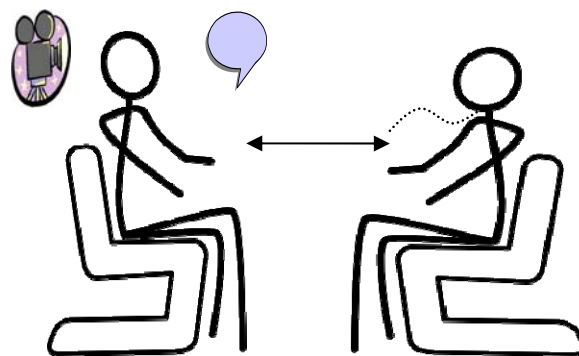


Figure 4.3 Condition B Co-Constructed Narrative Game a schematic illustrating the protocol.

Gesture stream exemplar

Co-participant Code: NAT- CP5		Story Line: ‘Cowboy rides into town’	
<i>No. in sequence</i>	Principal enaction descriptor Fragment of narration	<i>No. in sequence</i>	Principal enaction descriptor /Fragment of narration
1	<i>Cowboy on horse rides into town</i>	21	<i>Push money away</i>
2	<i>Lasso</i>	22	<i>So-long</i>
3	<i>Push open saloon doors</i>	24	<i>Push out of saloon doors</i>
4	<i>Do you want a beer stranger?</i>	25	<i>It’s raining</i>
5	<i>Response</i>	26	<i>It’s bright</i>
6	<i>A dollar</i>	27	<i>There’s a rainbow</i>
7	<i>Put money on bar</i>	28	<i>Listen</i>
8	<i>Catch beer glass</i>	29	<i>Dust down clothes</i>
9	<i>Smoke cigar</i>	30	<i>Pat horse haunches</i>
10	<i>Stranger 1 ‘tall’</i>	31	<i>Lead horse by rope</i>
11	<i>Large/fat</i>	32	<i>Shake hands ‘howdy stranger’</i>
12	<i>Knock on door</i>	33	<i>Hammer/request horse to be shod</i>
13	<i>Open door</i>	34	<i>Beckon daughter</i>
15	<i>Money on table</i>	35	<i>Violin</i>
16	<i>Deal cards</i>	36	<i>Look at hills (distance)</i>
17	<i>Look at others</i>	37	<i>Point to hills</i>
18	<i>Check cards</i>	38	<i>Stare</i>
19	<i>Play cards</i>	39	<i>Pay money to blacksmith</i>
20	<i>Gather money</i>	40	<i>Shoot</i>
		41	<i>Wave goodbye</i>

Illustration of 41 isolated gestures enacted during approximately 30 minutes of co-constructed narrative repertoire interaction

Table 4.6 Summary of principal verbal descriptor of target enaction embedded in the narrated story script

4.3.4.3 Condition C Manipulation of Veridical Artefacts

The third condition involved interaction with veridical, i.e. physically present, objects with which the co-participating young person was encouraged to interact. This condition is targeted at young people who may have performed with a reduced rate of success in the charade condition. The interaction typically involved imaginary play. The play could be described as everyday or fantasy scenarios. The everyday scenarios were improvised around e.g. play food such as fruit, doughnuts, slice of pizza, chips, lettuce, burger and chicken drum stick. It should be noted that all the young co-participants were tube fed in their everyday lives, i.e. would not experience eating and chewing successfully using their mouth and teeth as they have oral/digestive difficulties. The fantasy scenarios were improvised around more unusual objects such as a string of beads, bubble wrap scraps, chocolate, jelly or animal moulds etc. Details of the interaction protocols are provided in the appendices. The interaction is schematically illustrated in Figure 4.4. The star graphic is illustrative of corporeal enaction, i.e. micro-gestures performance by co-participating child, seated on the right, with associated corporeal dynamic features and narrative features. Exploration is afforded by artefacts, illustrated by collection of graphics in central block. Context is participatory design session with researcher, seated on the left. Therapist is not shown; all sessions are videotaped.

Condition C
Artefact Manipulation
Child is supported to produce manipulation of artefact within imaginative play, i.e. to encourage and develop micro-gesture potential useful for tangible interfaces.

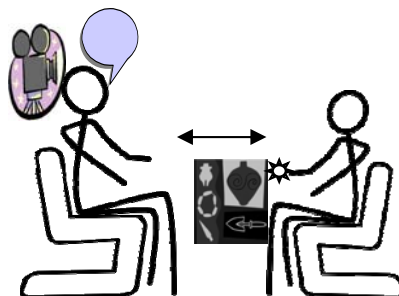


Figure 4.4 Condition C Manipulation of Artefacts Game Schematic illustration.

4.4 Summary

In this chapter I have framed the context of my empirical study. My study involves the qualitative re-examination of neuro-atypical gestures of children with severe speech and motor impairment due to cerebral palsy. I identify the need for more robust methods for the study of child gesture as intentional action. I highlight the need for both interaction paradigms and annotation systems that can inventory or classify a wider range of intentional movements. I provide support for an ecological interaction paradigm (i.e. rather than traditional empirical paradigms used to examine action) that allows the child to draw from their own resources to produce gesture repertoires. This is particularly relevant for neuro-atypical children who have compromised resources. I make the argument that such methodologies need to be inclusive.

I identify the challenges of existing qualitative and quantitative methodologies involved in the elicitation, capture and analysis of child gesture. These considerations of the methodological challenges are used to a) inform the empirical study; b) to validate the methodology and c) in the interpretative phenomenological analysis.

The level of annotation available to conventional gesture notation systems does not provide the level of granularity needed for the analyses and interpretation of enactive gesture. Limitation of conventional classification and inventories of movement, communication and cognition are similar in that they rely on deficit models when considering neuro-atypical children. These conceptual frameworks are incompatible with the enactivist paradigm used in my thesis.

I provide summary details of the Child Gesture Corpus, the selection criteria and data for the three case studies. I outline the methodology that supports the three ludic interaction protocols that were designed to provide opportunities for neuro-atypical young people with severe speech and motor impairment due to Cerebral Palsy to enact gestures. Using conventional descriptions, these protocols provide perceptual stimuli in different sensory domains: the audio-visual domain, i.e. speech alone, and the haptic domain, i.e. manipulation of physical artefacts.

Importantly, my ludic interaction paradigm is not based on a deficit model but on a phenomenological model of interaction that focuses on the self-regulation of the individual in relation to the social other. It can be used to *structure interactions* to allow for opportunities for the emergence of more complex gestures, even in children with impairment.

Six qualitative research criteria influence the sampling that underpinned the selection for the case study methodology. They are specified for this thesis in brackets: *Stakeholder* (child and their inter-actors within their ecology of interaction), *Extreme* (children with cerebral palsy), *Paradigmatic* (gesture as intentional action), *Criterion* (neuro-typical children and children with CP), *Theory-guided* (biological system theory) and *Expert* (child and researcher-practitioner)

The rationale for these selection decisions related to four aspects of *construct validity*. In the first instance it was to ensure that further annotation and analysis would provide *new* insights; secondly, the phenomena cannot be annotated or analysed for a deeper understanding using conventional methodologies; thirdly, the construct of Cognition in Action is supported by convergent data. The gesture exemplars from these children provide the starting point to generate meta-data sets for interpretation presented in chapter 6 onwards.

In chapter 5 I outline the two tools I have developed to support the analyses of child gesture: a feature action-based annotation system tool (G-ABAS) and the Interpretative Phenomenological Analysis tool adapted for gesture (G-IPA).

Chapter 5 Tool Development

5.1 Introduction

This chapter introduces the Gesture-Action-Based-Annotation-System (G-ABAS) together with an adapted Interpretative Phenomenological Analysis for gesture (G-IPA). These tools have been applied to the annotation and interpretation of video exemplars from the corporeal gestural repertoires of children. The analyses specifically address the three aims of the thesis presented in the ensuing three chapters. This chapter is presented in the following sections: in section 5.2 I give the *background to the conceptualization of the G-ABAS in the context of the challenges presented by video analysis including annotation*; in 5.3 I present the *G-ABAS ontology*; in 5.4 I present the *Interpretative Phenomenological Analysis adapted for the study of corporeal gesture (G-IPA)* and in 5.5 I outline the *Limitations, Advantages and Potential Applications of G-ABAS and G-IPA*. The chapter ends with a *summary* in 5.6.

The annotation system provides a framework for investigating gesture at a feature-based level. Fine grained annotation and layered analysis is presented of the video recordings of the selected exemplars from children's enactions. The G-ABAS and IPA tools are used to isolate *corporeal dynamic* and *narrative features* and create a meta-data set. These analyses and discussions specifically address the three aims of thesis. Chapters 6 and 7 illustrate how these tools are applied to the three case studies.

5.2 Introducing the Body Gesture-Action-Based-Annotation-System

In the previous chapter I identify the need and validate the rationale for developing extended gesture topologies. Such topologies can inform the enactive paradigms in cognitive neuroscience generally, and specifically the Cognition-in-Action theoretical framework.

5.2.1 Body Gesture Space

Figure 5.1a) illustrates a schematic conceptualization of 3D body gesture space within a notion of an imaginary sphere presented for the C-i-A framework. This concept of gesture space informs the enaction paradigm used in the interaction methodology and the manual annotation within the G-ABAS. Annotation codes are provided in appendix A. The visual form of Figure 5.1 a) was influenced by representations from both antiquity (see for example Leonardo da Vinci's Vitruvian man c1490) and work in the 19th century, Austin Gilbert's Chironomia (1806), Bacon's Manual for Gesture (1875) and Adams (1891). In contemporary

work this notion includes the work of Laban in dance with his use of the *Kinesphere* (1966) and in corporeal mime the work of Decroux (1985) see also chapter 4.

In Figure 5.1 b) *Vitruvian Man* is displayed to illustrate the potential compatibility of the C-i-A *gesture space sphere* conceptualization with joint point analysis approaches. Such mappings are typically used in human movement studies and computer-based gesture studies. In addition, such an anatomical conceptualization underlies commercial motion-sensor tracking technology, i.e. marker and camera-based systems. These technologies have a history of being used for gait analysis in rehabilitation, and for gesture recognition, e.g. Flock of Birds, Optotrack™, and Kinect™. More recently, technological advances are making available non-camera based sensor suits, e.g. Xsens™. This is of particular relevance to the third aim of this thesis.

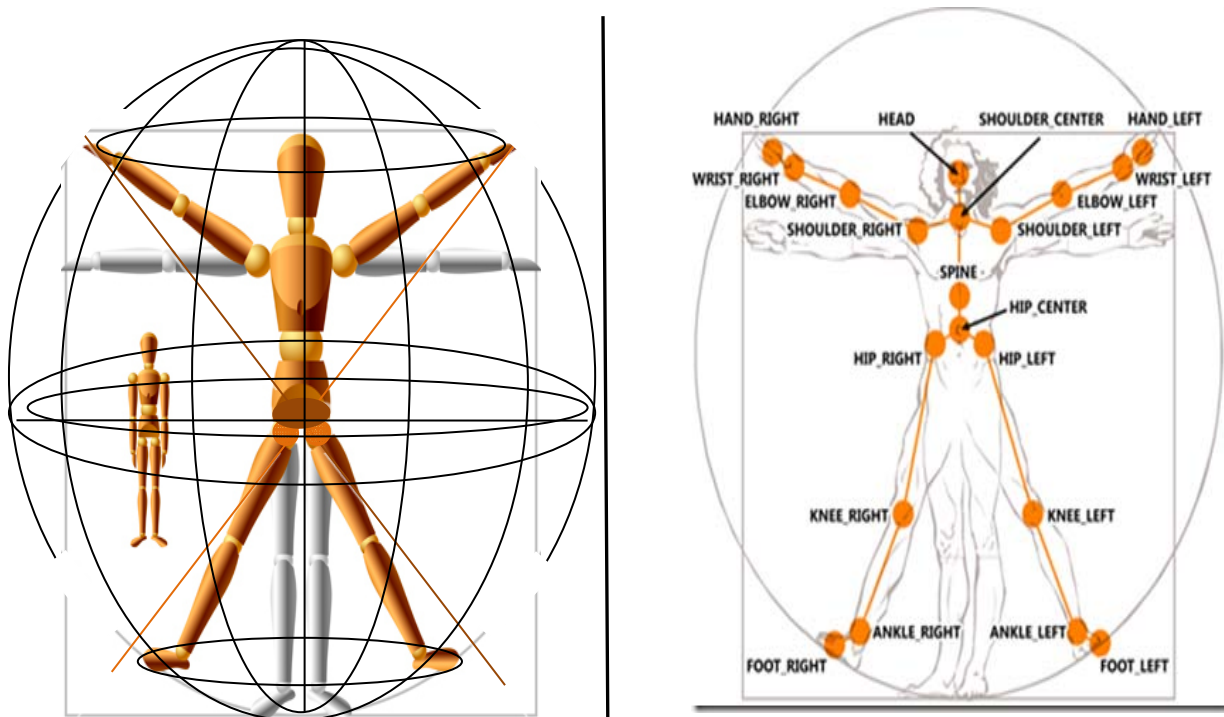


Figure 5.1 a) (left) A schematic conceptualisation of 3D *gesture space sphere* for the C-i-A framework and **Figure 5.1.b)** (right) An example of Leonardo da Vinci's *Vitruvian man* c1490

5.2.2 Challenges of Video Analysis

This section examines two challenges that relate to exploring the phenomena of child gesture: *video data capture and notation*. The challenges of eliciting gesture from neuro-atypical children with severe speech and motor impairment are not trivial. This has been discussed in the previous chapter, the introduction and the review chapter.

Here I focus on summarising four areas that need to guide research dealing with video analyses, namely: *selection*, *analysis*, *technology* and *ethics*, after Derry et al. (2010). They are listed with their descriptions in Box 5.1 a) below.

- ❖ **Selection:** *How can researchers be systematic in deciding which elements of a complex environment or extensive video corpus to select for study?*
- ❖ **Analysis:** *What analytical frameworks and practices are appropriate for given research problems?*
- ❖ **Technology:** *What technologies are available and what new tools must be developed to support collecting, archiving, analyzing, reporting, and collaboratively sharing video?*
- ❖ **Ethics:** *How can research protocols encourage broad video sharing and reuse while adequately protecting the rights of research participants who are recorded?*

Box 5.1 a) Foci of video analyses areas of study, applied to my empirical study, after Derry et al. (2010)

These have been previously discussed by Lemke (1995) and are typically met by contemporary child gesture researchers. However, Derry and colleagues highlight the fact that many challenges remain, not least the issue of bias that results from professional vision as identified by Goodwin (1986), who stated that:

‘psychological studies have shown that people often “see” events similarly in terms of causal, behavioural, and thematic structures, through professional vision,’ (Goodwin, 1986)

5.2.2.1 Video Analysis and Neuro-atypical Gesture

The empirical study presented in my thesis uses a blend of inductive and deductive approaches. The inductive approach was previously applied to the subset of the video corpus originally collected to examine the potential gestural capacity of children with severe speech and motor impairment for the purpose of the computer recognition of gesture see Roy (1996). These exemplars were considered in as much of their entirety as was practicable. These original analyses were not supported by any strong ‘*orienting theory*’, (Derry et al. 2010), p.7), but did involve successive and iterative viewing for points of interest see Erickson (2006) cited in Derry et al. (2010). These original analyses had the advantage of a computer graphic body model re-constructed from 3D motion capture data. These tools were used to support the inter-observer agreement on the ‘gestalt’ nature of the neuro-atypical gesture exemplars. It should be noted that this manual gesture annotation was limited to body part involvement and three gesture types: *static*, *single movement* or *periodic movement*. My thesis extends this work significantly.

My empirical study extended the original Child Gesture Corpus, combining a deductive approach, supported by Biological Systems Theory (BST), Dynamic System Theory (DST), and enactivist paradigms to develop the Cognition-in-Action framework. I

develop a comprehensive body-based gestural action focussed annotation system (G-ABAS) that can be applied for the first time to my knowledge to both neuro-typical and neuro-atypical child gesture (only neuro-atypical exemplars are presented in my thesis). The annotation tool is used in conjunction with an adapted Interpretative Phenomenological Analysis (IPA) tool. Once again the IPA is typically used for the analysis of text and for the first time I have extended IPA for the analysis of child gesture. These tools supported the analyses of both corporeal dynamic and corporeal narrative feature patterns in the three case studies presented in chapter 4 onwards.

Importantly, Derry et al. (2010) identify the complexity of dealing with video data, even with the use of narrative approaches such as '*disciplined subjectivity*' derived from ethnography. Bateson (1984) and '*rich descriptions*' used by Geertz (1973), both cited by Derry, 2010, p.11, indicate the challenges that remain are far from trivial.

In my analysis I use and extend the technique of video analysis called *video montage*, and the notion of '*stories are organized as multi-party interactive fields*' proposed by Goodwin (1981). To illustrate this, Goodwin describes how meaning in stories emerges:

'The meaning that the story will be found to have thus emerged not from the actions of the speaker alone, but rather as the product of a collaborative process of interaction in which the audience plays a very active role.' (Goodwin 1986, p.283).

In his paper on audience diversity, participation and interpretation, Goodwin also refers to the complexity of analysis, for example in theatre (Goodwin 1986). He describes conversation and performance as being on a continuum. He refers in notes to the work of Schieffelin (1984) who examined ritualized performance in Kaluli society, where the audience is actively involved in story construction during performance (see also chapters 2 and 3, the work of Augusto Boal in Theatre of the Oppressed which influenced my co-participatory interaction methodologies, and Panayi et al. 2000). I would suggest that a better description would be of different levels of system complexity. Returning to the video montage technique, it involves text and mark-making annotation, e.g. direction of gaze, on sequences of video extracts (see chapter 6 onwards).

Goodwin makes four important points that have relevance to both an embodied approach and to my choice of video analysis. The technique has the potential to analyse detailed aspects of interaction. These are summarized in Box 5.2.b) below.

- ❖ *Take a reflective stance*
- ❖ *Examine temporal and sequential frameworks*
- ❖ *Go beyond descriptive capacity of language analysis*
- ❖ *Develop systems that can examine the semiotic fields of interaction*

Box 5.2 b) Advantages of video analysis, summarised after Goodwin (1986)

The first point relates to how methodologies heavily influence analysis:

'It is therefore necessary to take a reflexive stance with regard to the interplay between methods for recording and transcribing an event, the phenomena that alternative choices reveal or hide, and the kinds of analysis that can then be developed.' (Goodwin, 2002, p.2).

The second relates to how even in face-to-face interaction, there is a need to examine what is *embodied* in what are temporal and sequential frameworks of interaction, specifically that:

'talk is framed by the bodies of the participants. Records and analysis that include embodiment as well as talk and phenomena such as the records and tools of the archaeologists reveal that human beings are in fact working with a range of temporal and sequential frameworks as they organize action in a rich multimodal environment.' (ibid, p.3).

Thirdly, Goodwin argues, citing Goffman (1964), that what a focus on the

'descriptive capacity of language misses is that the production of talk-in-interaction-the primary matrix within which language emerges, is shaped, and functions as consequential action-is in and of itself a new, immensely powerful, and distinctively human form of social organization, one whose properties require detailed study.'

Fourthly, Goodwin proposes the notion of *semiotic fields*. These encompass both the sign systems (language and gesture) and the medium used to build these signs. These can be studied in the context of their *contextual configuration*, i.e. the particular set of semiotic fields that the participants treat as relevant to the organization of action at a particular moment, p.34. In summary he argues that:

'action is not built through words alone. Instead, participants accomplish action by using simultaneously quite different kinds of meaning-making practices which mutually elaborate each other' (Goodwin, 2002).

Goodwin makes the distinction between gestures that refer to what is being talked about and *participation displays*, e.g. body shifts and eye gaze that can signify engagement and disengagement. Here he adopts the term '*ecological huddle*' from Goffman (1964), that refers to '*an arena for mutual orientation, shared attention to a common environment and where collaborative action can be constituted*' (Goodwin, 2003), p.17). He describes participants as having the capacity to attribute complex cognitive, projection and inferential practices to their co-participants. These are in turn taken into account in the detailed organization of social action. Goodwin evokes the idea of a '*public locus of the constitution of temporally unfolding meaning and action.*' ibid.

I will discuss these aspects of interaction within the context of child gesture and ludic interactions in the ensuing chapters.

5.2.3 Challenges of Annotation

Communication, Motor Function and Cognition Inventories

In this section I place my work in the context of existing gesture, movement, communication and cognitive system classifications. This work reveals the need to be able to document both the existing *performance ability* and *performance capacity* of children. Existing systems rely largely on performance ability (see summary data in appendices). In addition, the *normative scales* provided by these classifications cannot reliably be applied to children who are older or have severe disabilities, as is the case with the data presented in my empirical study. Furthermore, several are reliant on informant reporting rather than direct observation.

As discussed in chapter 2, the WHO ICF model argues for the inclusion of three perspectives on assessment and intervention: *body structure and function*, e.g. anatomy and physiology including language subsystems; *daily activities*, e.g. functional tasks including communication; and *participation context*, e.g. home, school, work, community.

The system tools I develop have the capacity to explore and examine both *performance ability* and *performance capacity*. They are also inclusive, i.e. equally applicable to neuro-atypical and neuro-typical movement profiles and where necessary age independent. In the subsections that follow I briefly illustrate the limitations of existing communication [Communicative Function Classification Systems (CFCS)], motor [Gross Motor Functions Classification System (GMFCS) and Manual Ability Classification System (MACS)] and Cognitive Classification System (CCS) in relation to my broader theoretical construct of gesture as Cognition-in-Action. Further comparative details of these systems are provided in the appendices.

5.2.3.1 Communication Systems including Gesture

McNeill's gesture classification system is widely used in both psychology and developmental research. It has also been the basis of gesture classification in other research domains such as anthropology and human computer interaction and recognition. However, it has limited applicability for the neuro-atypical population studied in my thesis. The limitations of this classic topology are described in Box 5.2 c) below.

- ❖ *Linguistically focused on co-speech, this includes semantic meanings*
- ❖ *Not concerned with the dynamics of gestural action and*
- ❖ *Lacking granularity of classification it encompasses only five categories of gesture with a predominate emphasis on the use of the hand and hand shape.*

Box 5.2 c) Limited Applicability of Mc Neill's gesture classification system

The focus on hand features makes it particularly inaccessible to code the action of children with compromised ability to make hand shapes. Importantly, the level of description of gestural features is limited to facial eye gaze, deictic gestures, iconic and metaphoric gestures. Compared with the G-ABAS, little if any, attention is paid to the relevance of the *corporeal dynamic* or *corporeal narrative* features of the gestures.

In main stream research some researchers do argue both for a dynamic model of communication (Fogel, 1995), and a dynamic systems methodology for life sciences see Fogel et al. (2008). In addition, Lavelli et al. (2003) and Lavelli (2010) have also successfully applied microgenetic design and analysis methodologies for tracking real-time dynamics in mother infant interactions. However, these methods are not typically used in neuro-atypical communication studies.

In the domain of communication rehabilitation Brady et al. (2012, p.5-6) carried out a systematic review of speech and language therapies. This review provided me with the opportunity to identify six key limitations for existing practices. These are summarized in Box 5.2 d) below.

- ❖ *No gold standards are in place for what to include in terms of early communicative skills*
- ❖ *There is little agreement on what skills represent symbolic or communicative acts*
- ❖ *The optimal method for complete assessment needs accumulation of multiple sources*
- ❖ *Existing systems with scales lack sensitivity to identify subtle changes in complexity of communication, this includes gestural communication*
- ❖ *Most systems focus on both a limited and non-inclusive set of behaviours.*
- ❖ *Where systems provide standardized scores, these normative scales cannot reliably be applied to children with severe communicative challenges, particularly those who are older*

Box 5.2.d) Limitations of speech and language therapies, summarised after Brady et al. (2012)

In terms of communication, it should be noted that limited work has been done on the development of next generation AAC devices that could potentially harness a greater range of intentional action; despite the fact that AAC devices are making positive impacts on the life of children with functional impairments; for a review, see Henderson et al. (2008).

5.2.3.2 Movement Classification Inventories

The movements of neuro-atypical children are once again typically examined within the framework of ‘deficit’ or ‘atypical movement patterns’. Such approaches greatly influence subsequent intervention paradigms that aim to rehabilitate function to the ‘gold standard’ as the norm. Such programmes are supported by traditional models of motor control (see chapter 2). Existing movement classification systems for cerebral palsy focus on performance in

everyday situations, i.e. *only functional action not gestural action per se*. For details of the Gross Motor Function Classification System (GMFCS), see Palisano et al. (2000) and for hand performance (MACS), see Eliasson et al. (2006). The original (GMFCS) system did not include children beyond 12 years of age; the system was extended to encompass children up to 18 years (i.e. the age range of children included in this study) in 2007 see GMFCS-ER, Rosenbaum et al. 2008. Typically, such systems are used for diagnostic and/or research purposes. These systems are concerned with documenting movement or communication per se, but *not capacity* for movement and/or communication.

In contrast the focus of G-ABAS is on documenting such movements in the *context of a child's performance capacity* in interaction with the self, social other and other as artefact. Further details of the annotation coding that can be used by expert coders can be found in the appendices. My empirical study presented in chapter 4 onwards illustrates how the G-ABAS can be applied to child gesture. The tools I have developed are consistent with alternative models of motor control that favour the conceptualization of the motor control as a dynamic and non-linear system. Such models are beginning to influence a gradual shift in intervention practices; for a review in the context of cerebral palsy, see Hadders-Algra et al. (2010).

In terms of movement the standard classification system, i.e. Gross Motor Function Classification System (GMFCS), was developed after the initial corpus was collected. Retrospectively the neuro-atypical children with cerebral palsy who contributed to my corpus can be classified with respect to their gross functional movement as being between the lower end of Level IV and Level V. In these cases young people are transported in a manual wheelchair in all settings. In terms of ability they are limited in:

'their ability to maintain antigravity head and trunk postures and control arm and leg movements. Assistive technology is used to improve head alignment, seating, standing, and mobility but limitations are not fully compensated by equipment. Physical assistance from 1 or 2 persons or a mechanical lift is required for transfers. Youth may achieve self-mobility using powered mobility with extensive adaptations for seating and control access. Limitations in mobility necessitate adaptations to enable participation in physical activities and sports including physical assistance and using powered mobility.'

In terms of the Manual Ability Classification System (MACS), they could be classified as being at level IV- V, i.e. *'IV Handles a limited selection of easily managed objects in adapted situations; performs parts of activities with effort and with limited success; requires continuous support and assistance and/or adapted equipment, for even partial*

achievement of the activity.' and '*V Does not handle objects and has severely limited ability to perform even simplest actions and Requires total assistance.*' (Eliasson et al. 2006).

Both the MACS and GMFCS are designed for rating functional every day movement in the real world with real objects and for rating performance activity and not *capacity*. Dematteo et al. (1992) observed that such systems are '*unlikely to be responsive to important changes in motor function which may have occurred as a result of therapy*' (ibid, p.2). Thus they may be lacking in one or more of the effectiveness criteria for such instruments, specifically: '*clinical utility, construction and scaling, standardization, reliability, validity and responsiveness*' (ibid, citing Law, 1987). For a review and discussion with respect to hand function, once again refer to the QUEST manual by Dematteo et al. (1992).

In contrast, my conceptual framework is concerned with the underlying process of complex movements. It focuses on understanding the emergence of performance capacity in *moment-to-moment* interactions. It has the potential to meet the seven effectiveness criteria outlined by Law (1987), in particular the criteria of responsiveness, i.e. *sensitive to change within individuals* cited by Dematteo et al. (1992), p.2.

Furthermore, such conventional approaches to the study of motor action confine movement consciousness to some or all of the realms of '*purposive, calculative, information processing and reduces the elemental gestures of movement to schemas of psycho-motor skills acquisition*' (see Smith, 2007, p.66). This applies to both movement studies that focus on rehabilitation and those that use neuro-imaging technology to further understanding of underlying mechanisms, i.e. *neurological correlates of action*. The majority of motor control studies focus on rehabilitation as a means to restore some level of functional movement for children with CP see Steenbergen and Utley (2005) and Steenbergen and Meulenbroek (2006). For reviews of work on the role of posture in CP action, see Hadders-Algra et al. (2005).

In terms of therapeutic practices Wilson (2006) provides an evaluative review of theoretical approaches in this area. His recommendations included that the field of physiotherapy should consider dynamic system and neurocognitive approaches.

I would argue that, as with the review for speech and language therapies, the movement classification systems including the GMFCS have similar limitations. These are listed and described in Box 5.2 e) below.

- ❖ *No gold standard that is inclusive of **neuro-typical and neuro-atypical movement** without recourse to deficit models of movement*
- ❖ *Motor classification is **limited to functional movement***
- ❖ *The **optimal method** for complete assessment still needs **accumulation of multiple sources***
- ❖ *Existing systems with scales **lack sensitivity** to identify **subtle changes in complexity and non-functional movement***
- ❖ *Most systems focus on both a **limited and non-inclusive set of behaviours**.*
- ❖ *Where systems provide standardized scores, these **normative scales are typically used when children are between 2-4 years old, i.e. there is no provision in the system for documenting progressive or emergent capacity.***

Box 5.2.e) Limitations of movement therapies, summarised after several authors

5.2.3.3 Cognition and Gesture

As with the assessment of communication and motor functioning, the traditional cognitive assessment of children with physical disabilities can be challenging and as a result the:

‘nonverbal reasoning abilities of children with CP may go undiagnosed’ ... ‘This is especially the case for children in the dyskinetic CP or quadriplegia subgroups’ (Sigurdardottir et al, 2008, p.361).

Importantly, 10-15% of children with CP typically cannot access traditional assessment measures such as the Wechsler scales, which are normed on neuro-typical children and adapted for neuro-atypical children. This often results in these children being *‘grouped with children with IQ<50s and/or their assessment is partial or solely based on clinical evaluations’* (ibid, p361). A range of developmental scales were used for aspects of cognition; these have been summarized in the appendices. It should be noted that these scales have been normed on children in the USA. The list was derived from that presented by Sigurdardottir et al. (2008, p.358). A key finding from this comprehensive study of cognitive skills conducted with a large cohort of children with CP was that *‘cognitive skills can be masked by limitations of movement and motor control in children with CP’* (ibid).

Furthermore, these researchers noted that although typically children with spastic hemiplegia and diaplegia had *‘better outcomes than children with spastic quadriplegia and dyskinetic CP’...* a significant proportion of children had good nonverbal reasoning abilities’ (ibid, p361). In addition, the authors report that the *‘median IQ scores are lower in children with CP than the general population, although a significant proportion of children have scores in the normal range’* (ibid, p362). In the field of speech and language therapy some researchers and practitioners are developing dynamic assessment protocols see Law and Camilleri (2007).

Such findings provided further support for the argument put forward in my thesis for the need for both a closer examination of cognitive skills and the development of measures that can inform interventions to develop spatial-cognitive skills of intentional action. This is discussed further in ensuing chapters where I propose the use of G-ABAS in conjunction with

G-IPA and the Cognition-in-Action framework as a potential measure for Spatial Kinaesthetic Interaction and Intelligence (SKIP) (Panayi in prep).

5.2.4 Data Capture and Annotation Technologies

Finally, in this section I briefly consider the methodological issues that arise with the increased availability of wired (body sensors) and wireless (optic/body marker) technology and associated software for the measurement of movement. Such technologies are contributing to research that examines the dynamic dimension of gesture (see chapter 2). The original study (Roy, 1996) captured both video data and used x, y, z motion sensors to capture gesture movement. The latter data are not considered in my thesis. I focus solely on the qualitative analysis of video gesture data.

Existing methodologies currently lack the ability to combine data capture, re-composition and standards for sharing data across disciplines. Furthermore, open questions still remain around the issue of occlusion, capture, and data analysis of rapid movement in general and in particular neuro-atypical movement profiles, such as those seen with cerebral palsy. I would also argue that such limitations are compounded by the lack of a deeper understanding of gesture as dynamic, enactive and interactive phenomena.

A case in point in terms of annotation is the existing computerised analysis tools such as: CLAN (Computerised Language Analysis tool) for TalkBank, ELAN (EUDICO Linguistic Annotator), NEUROGES-ELAN (used largely for the analysis of co-speech hand movements) and ANVIL (Video annotation tool). Although all are efficient annotation tools, they still lack support for '*reflection, sharing or commentary*' (Derry et al, 2010, p.25). In addition, they lack the granularity to annotate complex enactions, particularly those involving more than one person.

Finally, Derry suggests that the community is still in its infancy and is '*in the beginning stages of figuring out as a field creative ways to achieve compelling representations of complexity*' (Derry et al, 2010, p.24).

5.3 G-ABAS Ontology

5.3.1 Background

The body gesture Action Based Annotation System (G-ABAS) provides an alternative ontological framework to annotate features present in gestures *enacted as performance*. Earlier versions of the system were developed to annotate both neuro-atypical and neuro-typical child gesture. This work informed research on two projects: one on standards in language engineering (ISLE, Roy et al. 2000) and one on the development of wearable technology for children (Today's Stories, Panayi et al. 2000). The G-ABAS tool was developed based on observations of children's gestures and is informed by models of knowledge organization and research into the potential mechanism that underlies neurology of gesture.

5.3.2 Current Version

The current version has been developed by the author of this thesis. It was influenced by early work on rhetoric and gesture in antiquity (see chapter 2). Successive viewing of the gesture exemplars supported the development of the annotation system ontology. The gesture-as-action construct and the ludic interaction paradigm supported a gesture-in-performance framework that allowed a range of influences to be considered. This approach supported the development of an inclusive feature based annotation system that has the capacity to annotate over 260 features.

The qualitative annotation features for G-ABAS are organised across two main themes described as: *Phase One: Corporeal Dynamics and Phase Two: Corporeal Narrative*. *Corporeal Dynamic* features are those that describe *motion events* of the body/body parts in 3D egocentric space that is reachable within in extra-personal gestural sphere. *Corporeal Narrative* features are those that relate to sense-making in interaction. The second phase was informed by adding data from neuro-typical children and re-examining the gesture corpus of neuro-atypical children. It can support the progressive annotation of features. Each theme comprises of five strands. Together with the adapted Interpretative Phenomenological Analysis for gesture (G-IPA) these tools iteratively influence the development of the Cognition-in-Action.

Phase One: Corporeal Dynamics This theme contains five strands. It has the capacity to code for over 160 features across 8 broad clusters. These are summarised in a body map diagram in Figure 5.2 and descriptors provided in Table 5.1.

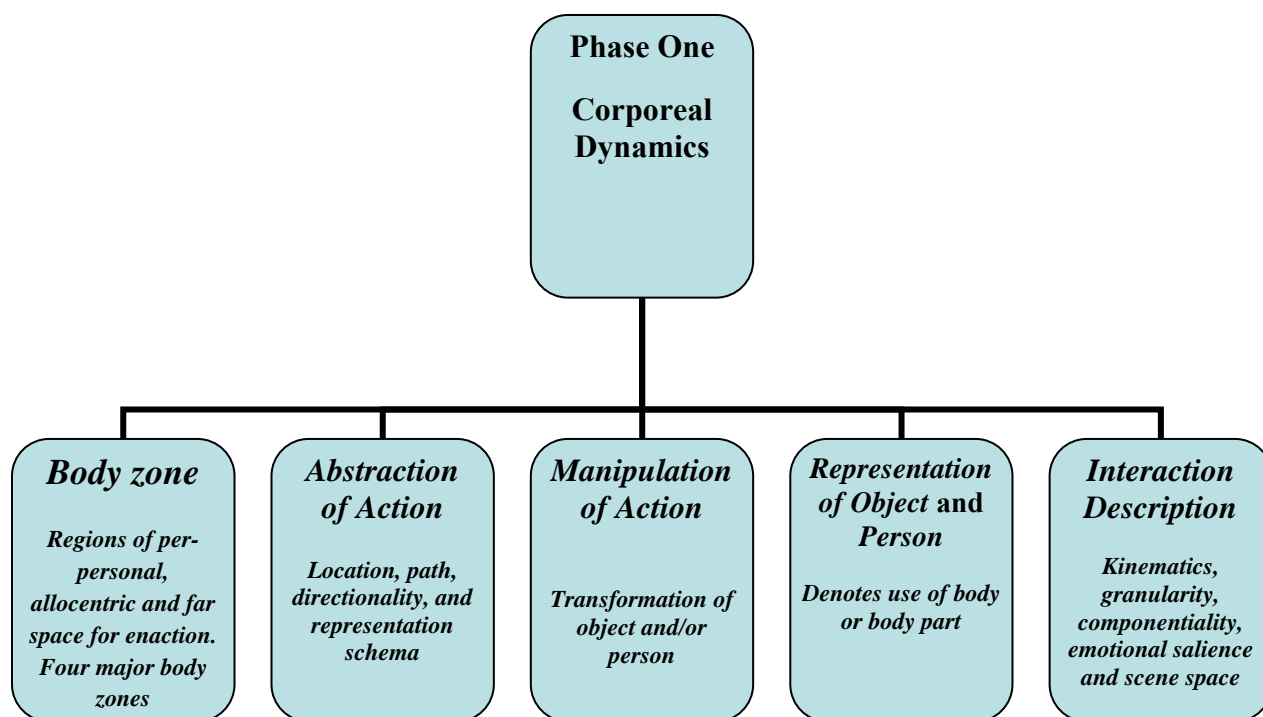


Figure 5.2 Body Map Theme Diagram

Themes Five Strands	Descriptors and subthemes
Corporeal body zone involvement	The <i>Corporeal Sphere</i> describes the regions of <i>egocentric</i> , <i>allocentric</i> and <i>far space</i> for enaction. This anatomical system is defined by its degrees of freedom and constraints. These constraints may be significant in the case of neuro-atypical children. Within the sphere <i>four major body zones</i> are described as <i>initial regions of interest</i> (ROI). They are described as: 1. head/face; 2. arm/torso/hand; 3. lower body and 4 whole body. <i>A scale</i> is available to describe the level of independent involvement, e.g. 1- no response; 6 - novel gesture.
Abstraction of Action	<i>Location, path and directionality, representation schema</i> , e.g. a child may choose to trace the path taken by the imaginary tennis racket handle in a volley
Manipulation of Action	Described in terms of <i>transformation of objects</i> , e.g. to part of virtual object, to part of real object, additional other manipulation. Also the <i>transformation of person</i> , e.g. the self to social other, e.g. the twisting of the wrist in relation to the volley
Representation of Object & Person	Denotes the use of the <i>body or body part</i> in relation to a veridical/real and/or imaginary object, e.g. tennis racket handle
Interaction Description	For example, playing tennis with an imaginary object and social other such as your opponent. It can refer to movement features such as: <i>Kinematics</i> , e.g. velocity, speed, deceleration; action geometry, e.g. volume, shape, axis; <i>Manner</i> , e.g. effort, bimanual, symmetrical, pose. <i>Granularity</i> refers to, for example, the of nature macro/micro aspects of the environment. <i>Componentiality</i> refers to the elements that may be combined such as: action geometry, kinematic, manner, effort in relation to scene (gesture) space. <i>Emotional salience</i> e.g. facial gesture/expression, body/body part posture and <i>Scene Space</i> other contextual points of interest

Table 5.1. Phase One Descriptors in relation to the themes for corporeal dynamic features, five strands

Phase Two: Corporeal Narrative

Narrative theory and the interaction paradigms provide the underlying framework for the development of Phase *Two: Corporeal Narrative*. This theme incorporates five strands (with capacity to code for over 100 features across 9 broad clusters). Five strands can be used to reveal aspects of corporeal narrative knowledge, specifically:

Source of narrative knowledge, e.g. imagination, ephemeral, binding; *Scale of narrative*, this relates to the coherence and fidelity and can be scored using three categories, e.g. story memory, quality and structure; *Narrative gesture space*, this includes the point of view (POV), deixis, the conceptual grounding for the story world. For enaction space, see narrative emotional space; *Manipulation of abstract thought*, these are exemplified, e.g. by mathematical, scientific and creative thinking. The last strand describes the *Narrative Emotional Space*, e.g. in the context of what is described as ‘stage space’; with dynamics (see Interaction Description, in phase one). These are shown in the Body Map Diagram Figure 5.3 with the associated descriptor summarised in table form in Table 5.2

Analysis of the features in these strands reveals not only the story as a ‘*series of events*’ but also aspects of the story that are concerned with narrative ‘*fabulae*’ or elements that refer and contribute to the material content of the story. Such elements have been shown by other theorists, when applied to text, to be deep structures that are robust not only across narrative genre, e.g. cartoon, folk tales, cinema/film and theatre, but also cross-culturally. In addition, this gesture ontology can be used to annotate for features extracted from the ‘*mise-en-scène*’, i.e. those features that make up a visual or theatrical scene.

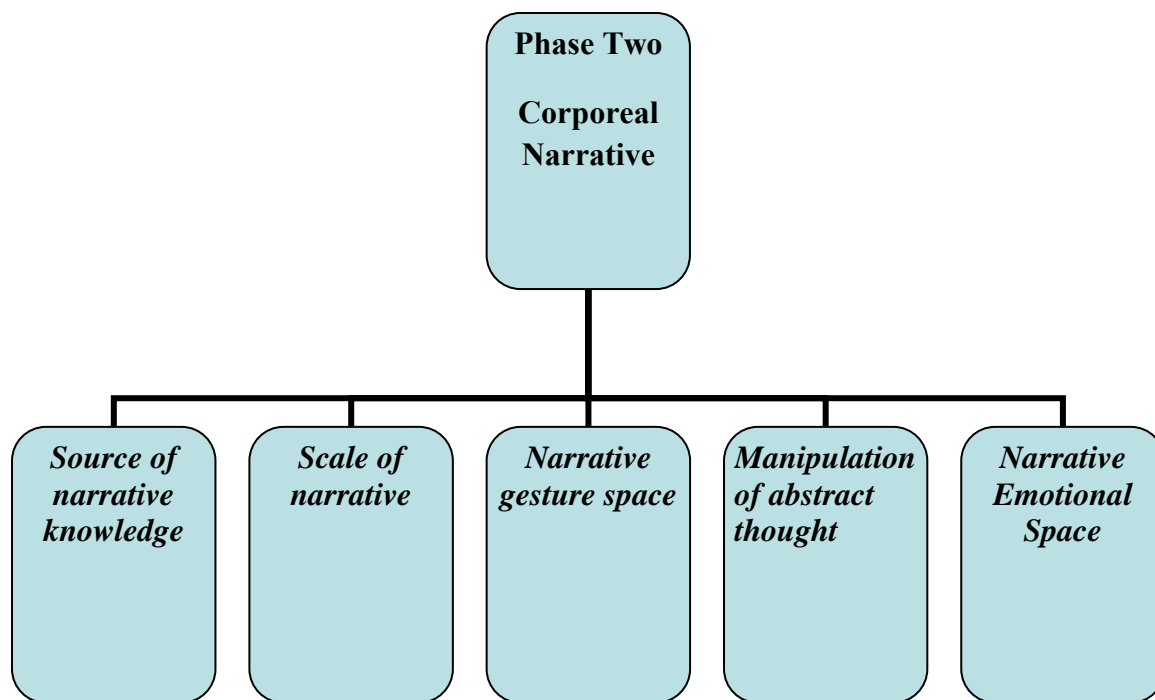


Figure 5.3 Corporeal Narrative Body Map Theme Diagram

Theme Five Strands	Descriptors and subthemes
<i>Source of narrative knowledge</i>	e.g. imagination, ephemeral, binding
<i>Scale of narrative</i>	This relates to the coherence and fidelity and can be scored using three categories, e.g. story memory, quality and structure
<i>Narrative gesture space</i>	This includes the point of view (POV), deixis, the conceptual grounding for the story world. For enaction space, see narrative emotional space
<i>Manipulation of abstract thought</i>	Can be exemplified by mathematical, scientific and creative thinking.
<i>Narrative Emotional Space</i>	e.g. in the context of what is described as ‘stage space’; with dynamics (see Interaction Description, in phase one)

Table 5.2 Phase Two Descriptors in relation to themes, five strands

Importantly, corporeal narrative features can be combined with gestural dynamics (Phase One). These data can be used to construct a Spatial Kinaesthetic Interaction and Intelligence Profile, henceforth denoted by (SKIP) for individual children. This will be illustrated in subsequent chapters.

5.3.3 Summary

In summary, the G-ABAS can be described schematically as a nested topology. The nested structure illustrates the associated logical relationship of the corporeal gesture features; therefore it could also be described as a network, see Figure 5.4 and Figure 5.5 below. However, the nature of the interconnectivity still remains unknown. In the following section (5.4) I illustrate the stages of the Interpretative Phenomenological Analysis applied to gesture (G-IPA), together with G-ABAS to instantiate and validate aspects of the C-i-A framework. The theme substructure and annotation system codes can be used by expert gesture researchers; further detail can be found in the appendices.

Future work in *Phase Three* will involve the development of the SKIP part of the tool. It will most likely be of interest to the gesture research community, pedagogic, therapeutic and clinical practitioners, who may wish to use dynamic assessment with neuro-atypical children, and to designers of future interactive technologies.

The potential applications, limitations and the threefold advantage of the G-ABAS and G-IPA are elaborated in subsequent chapters.

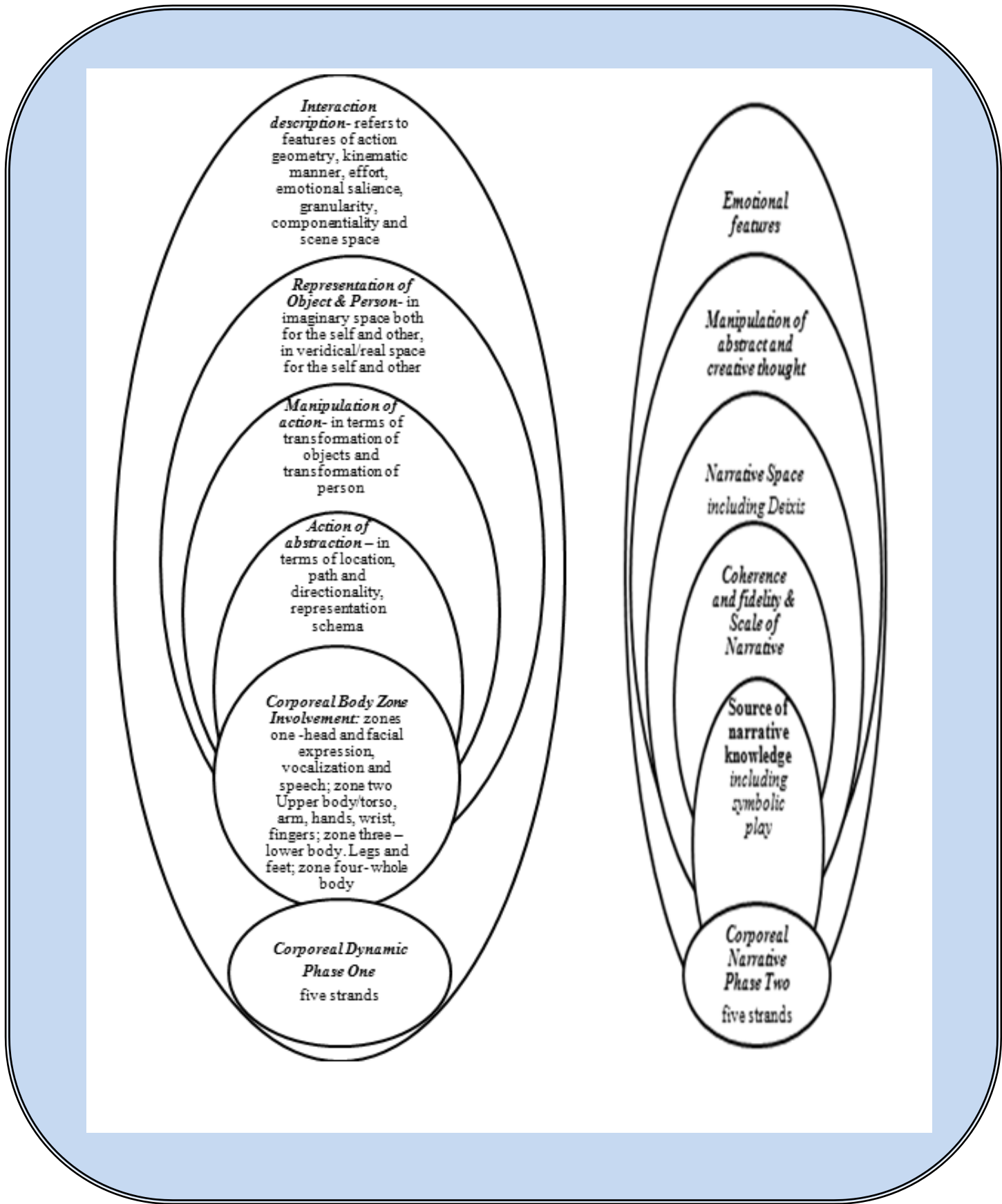


Figure 5.4 G-ABAS Simplified nested ontology. It illustrates the associated logical relationship of the corporeal gesture features for Phase One: Corporeal Dynamics and Phase Two: Corporeal Narrative, after Panayi (2012).

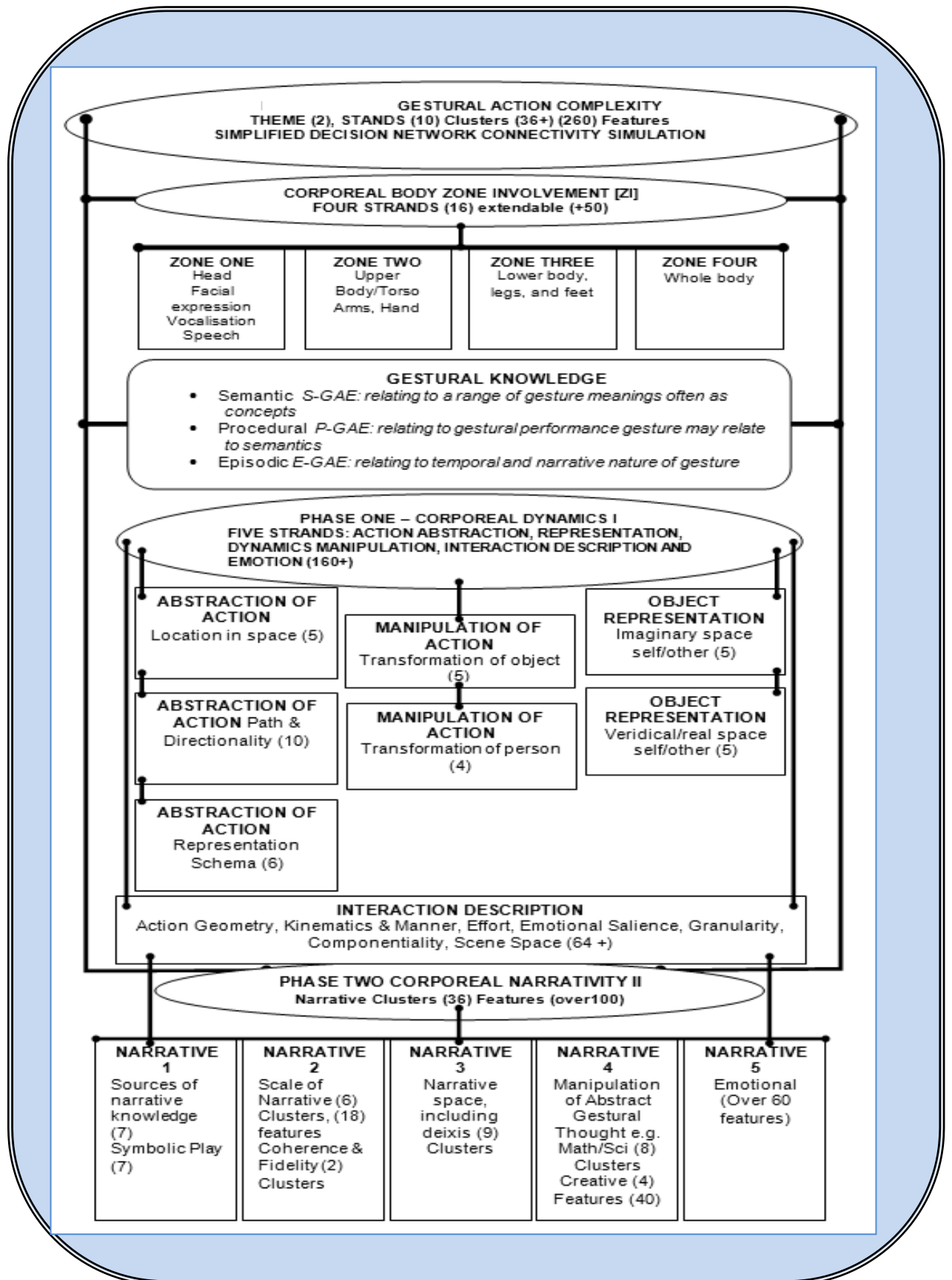


Figure 5.5 G-ABAS Gesture ontology illustrating the Phase One Corporeal Dynamics and Phase Two Corporeal Narrative Themes together with pattern clusters. Number of features is shown in brackets. The nested structure illustrates the associated logical relationship of the corporeal gesture features in relation to Gestural Knowledge described in terms of Gesture Action Entities. For details including codes, see appendices.

5.4 Interpretative Phenomenological Analysis Applied to Child Gesture (G-IPA)

5.4.1 Interpretative Phenomenological Analysis (IPA) Introduction

IPA is an inductive approach to psychological qualitative research with an idiographic focus. It can be used to explore relatively '*unexplored territory*', i.e. where a theoretical pretext may be lacking (Reid et al. 2005). IPA has its philosophical grounding in the *theory of interpretation* (hermeneutic) and the work of Husserl. For this type of exploratory stance focusing on inquiry and meaning-making, see Smith and Osborn (2008).

As a qualitative methodology in healthcare research, IPA is one that is gaining ground; see Biggerstaff and Thompson (2008). It demonstrates the capacity as a method for '*essential simplicity, paradoxical complexity and methodological rigour...for understanding healthcare and illness from the patient or service user perspective*' (ibid, 2008, p.214). Furthermore, in terms of Husserl's philosophy, Biggerstaff and Thompson (2008) summarise '*the meanings an individual ascribes to events are of central concern but are only accessible through an interpretative process*' (ibid, 2008, p.218). Thus, IPA is compatible with the theoretical framework that underpins the C-i-A framework. The method offers insights into a given phenomenon.

5.4.2 Gesture and IPA (G-IPA)

Although typically applied to text, e.g. interview, or questionnaire material, in this thesis it has been adapted for the analysis and interpretation of children's corporeal gestural repertoires. To my knowledge my work is the first that has developed IPA for the body-based analysis of non-verbal intentional action and specifically for child gesture. In *Stage 1* The first encounter with the gestural repertoire is experiential, and then involves several viewings of the video material; *Stage 2* involves the identification of preliminary themes. These may be either subordinate or superordinate. In *Stage 3* themes are grouped together as clusters. Stages 1-3 are re-iterated until saturation is reached for any given ludic interaction. For *Stage 4* themes are tabulated within the G-ABAS; the ontological framework is consolidated. *Stage 5* allows for the G-ABAS to have an open ontological structure, i.e. is responsive to new data. In *Stage 6* the G-ABAS and the IPA are used with selected exemplars from individual case studies to instantiate and validate aspects of the C-i-A framework. This is illustrated using stages, modified and visualised after a summary by Biggerstaff and Thompson (2008, p.225) and illustrated as a process in Figure 5.6.

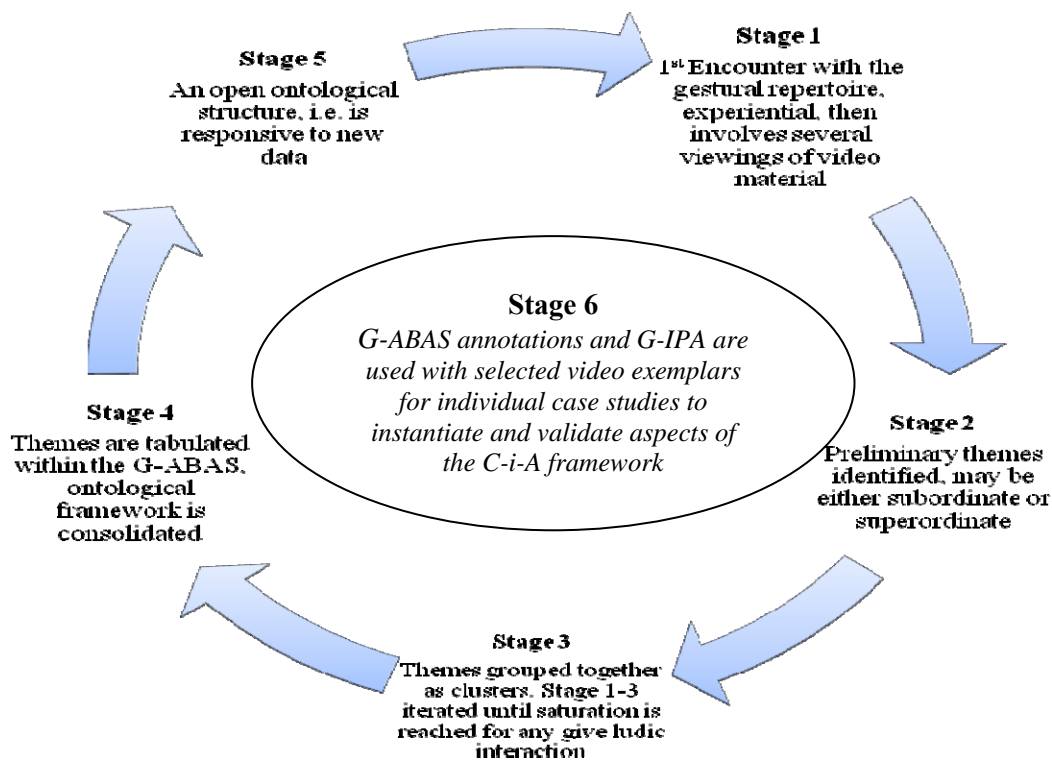
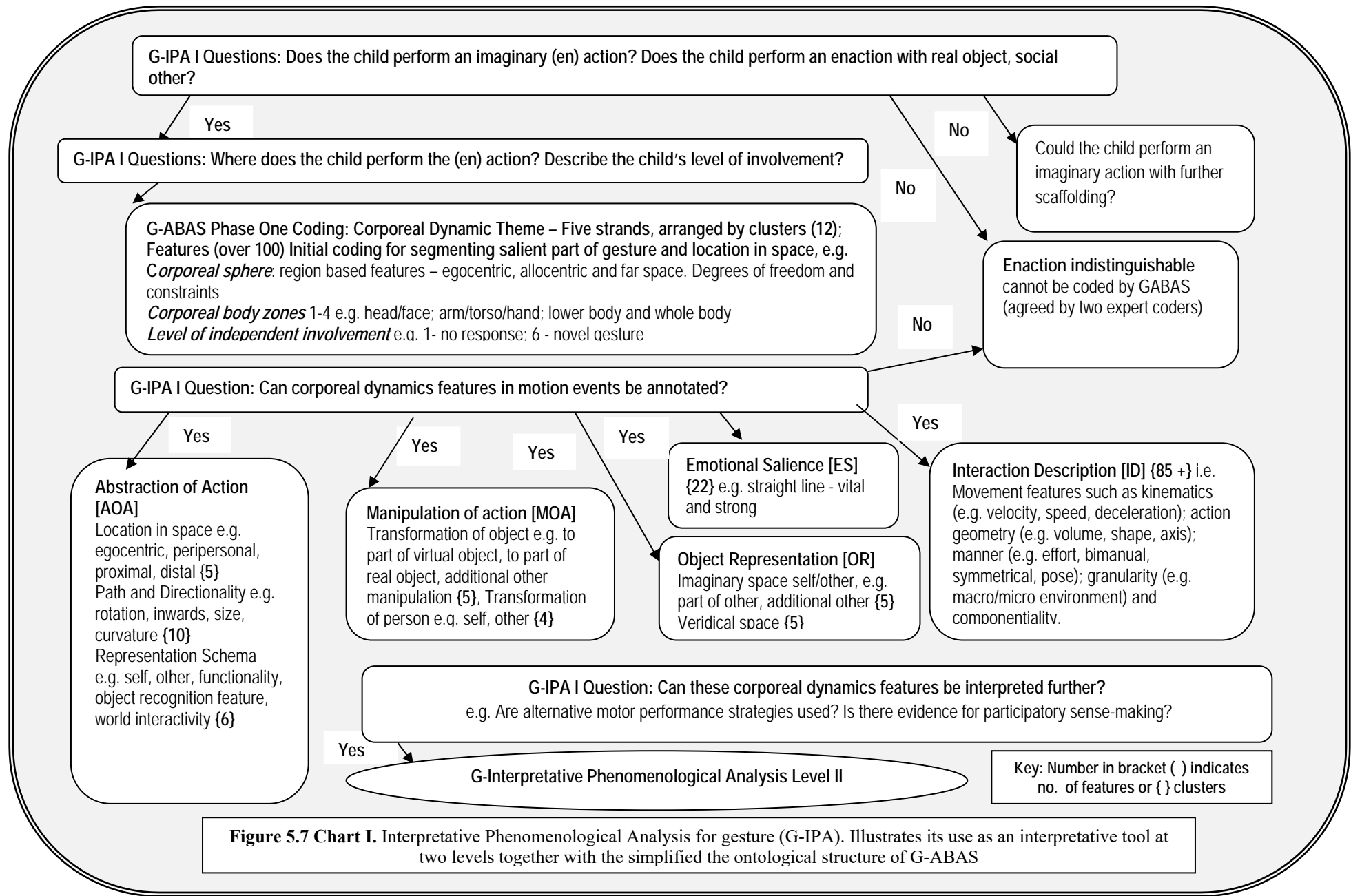


Figure 5.6 Interpretative Phenomenological Analysis (G-IPA) and G-ABAS applied to child gesture, developed and modified after Biggerstaff and Thompson (2008) see Panayi (2014) b.

A series of questions were constructed, supported by IPA and used interactively with the G-ABAS. Four questions are listed below in Table 5.3 for use with the first guide illustrated as Chart I in Figure 5.7. Chart II illustrates the second level of the G-IPA analysis and is presented in chapter 6

Level 1 of G-IPA Constructed Questions	Note taking and movement to next stage
<i>Does the child perform an imaginary (en)action? Does the child perform an enaction with real object, social other?</i>	<i>Initial observation whether from pre-recorded video or interactively. Best to have a second person making observation, if notes are being taken during a therapy/pedagogic/clinical session</i>
<i>Where does the child perform the (en)action? Describe the child's level of involvement?</i>	<i>Corporeal dynamic strands see contextual notes</i>
<i>Can corporeal dynamics features in motion events be annotated?</i>	<i>See corporeal dynamic strand descriptors</i>
<i>Can these corporeal dynamics features be interpreted further? e.g. Are alternative motor performance strategies used? Is there evidence for participatory sense-making?</i>	<i>Review initial data, reflective practitioner decision to progress to next level of G-IPA II</i>

Table 5.3 G-IPA Guide for constructing questions, note taking and reflecting to be read in conjunction with Guide



5.5 Limitations, Advantages and Potential Applications of G-ABAS & G-IPA

For issues that relate to the annotation of video, including its use in the analysis of co-speech gesture and an updated guideline for video researchers, see Derry et al. (2010) chapter 3. Lemke critiques transcription in linguistic studies (1995; 1998) and later in relation to eco-social perspectives Lemke (2000 and 2001). Four points have particular resonance for the validity of my work on gesture; these are summarised in Box 5.5 a) below.

- ❖ *Uniqueness of individual is paramount*
- ❖ *Care should be taken when dealing with non-homogenous populations, i.e. events do not represent a homogenous population, if sampled in isolation*
- ❖ *There are limitations to sampling and statistical analysis*
- ❖ *There is a value in data aggregation, i.e. enables consideration of co-variation that is culturally manifest*

Box 5.5 a) Limitation, advantages and potential value of video annotation, after Lemke (2000 and 2001)

Table 5.4 a) summarizes how G-IPA was developed and applied to data in my thesis. It shows how my feature analyses match eleven key methodological issues. Specifically, G-IPA has the capacity to enable the researcher to deal with a complex analysis involving, e.g. *interpretation, plausibility, ecological validity, topic focus, transparency, reflexivity*, as well as *cross-validation* and *integration* of research with practice. The IPA ontology is broadly compatible with ethnomethodological studies. Thus, it is in keeping with the theoretical framework of my thesis. It is also consistent within the ‘*broad premise of positive psychology*’; see Seligman and Csikszentmihalyi (2000) cited by Reid et al. (2005). Of direct relevance to this study is the role of IPA in three areas summarised below in Box 5.5 b).

- ❖ *Challenge to traditional linear relationship between the number of participants and value of research*
- ❖ *Focus on the idiography of the participants; and it successfully makes the case for the*
- ❖ *Advantages of small samples and single case studies*

Box 5.5 b) Advantages of IPA summarised after several authors

The inclusive nature of my empirical study requires methods that are better matched to both the heterogeneity and variability of the phenomena under exploration. Such methodological frameworks can support the analysis of both neuro-atypical and neuro-typical gesture data. Of particular interest to the third aim of this thesis is the application of G-IPA to, e.g. technology enhanced learning (Creanor et al. 2006a); for children’s wearable technology, see Kids’ Wearables, Panayi et al. (1998) and future pedagogy, Panayi and Roy (2012). In medical science, see Claassen et al. (2011) for a study that focussed on encouraging physical activity in adolescents with cerebral palsy.

Analysis Features and considerations	ISSUES	
	Accommodation to issue	Applied in this thesis
<i>Complexity and richness of data</i>	Can be reduced through rigorous and systematic analysis	Yes. Systematic empirical analysis, chapter 3 onwards. Abductive reasoning for synthesis
<i>Maintains ‘idiographic’ focus</i>	That which is distinct i.e. idiographic of the person, balanced with what is shared i.e. commonalities across participants	Yes, adapted for child gestural data. Presented in six case studies
<i>Interpretative</i>	Subjective, see reliability, cross validation	Yes. Systematic empirical analysis, chapter 3 onwards. Abductive reasoning for synthesis
<i>Ecologically valid ‘Open System’</i>	Ensure awareness and documentation of context. Need to be aware that this still remains a ‘snapshot’	Yes - Child Gesture Corpus, previously documented activity study for neuro-atypical children. Details of empirical study, see Ch.3 See appendix for Child Gesture Ecologically Valid Research Guide
<i>Themed</i>	Allows for generic qualitative approach. To provide topic foci, represent both commonalities and accommodate variation	Yes, successfully applied to both neuro-atypical and neuro-typical co-participant gestural repertoires. G-IPA adapted for both corporeal dynamic, narrative features, see G-ABAS
<i>Plausibility</i>	i.e. Participants’ ‘voice’ Allows for more substantial and discursive reporting	Yes, specifically to co-participating children, researchers, clinicians, teachers and the wide research community
<i>Transparent</i>	Grounded in examples from data	Yes, illustrative exemplars from children’s gestural repertoires
<i>Reflexivity</i>	On the part of the researcher	Yes, within context of role as research, teacher and academic therapist
<i>Cross-validation Triangulation</i>	e.g. more than one coder	Yes, two expert coders
<i>Inclusivity</i>	Balance of both ‘Emic’ (phenomenological, insider) and ‘Etic’ (interpretive, outsider role) positions	Yes, see introduction and discussion ‘Emic’ child co-participant ‘Etic’ co-participating researcher
<i>Integrate research and practice</i>	IPA has potential to be informative for applied research and impact on practice	Yes – embodied in all three aims of the thesis

Table 5.4 a) Applying the IPA to Gesture Analysis, Panayi (2012) the analysis features, consideration and issues, developed after Reid et al. (2005).

Potential Applications and Advantages

The potential applications and advantages of the G-ABAS are threefold and are elaborated in terms of its use as a tool for gesture studies. It has the potential for deriving evidence for developing corporeal profiles of children. More specifically, such profiles could be used as part of dynamic assessment instruments for neuro-atypical children with severe speech and motor impairment.

In mainstream research the G-ABAS has the potential to contribute to work on annotation, both in the broader domain of gesture research and more specifically to standardization work in language engineering. These potential wider applications and advantages are presented in Table 5.4 b).

Potential Wider Applications Advantages of G-ABAS applied to child gesture and coupled with IPA and the C-i-A framework

Annotation and coding system	Tool to aid the deeper understanding of gesture. The resulting annotation and coding system is feature and meta data based. It has the capacity to deal with macro and micro analysis of gesture at several levels of complexity.
Instrument for assessment	Potential instrument for dynamic assessment of children’s Spatial Kinaesthetic Intelligence. The final phase of development, G-ABAS, will provide a manual that profiles the progression in (SKIP). This would be of particular value to pedagogic, therapeutic and clinical practitioners working with neuro-atypical children and designers of future interactive technologies.
Standardized tools	As a contribution to standardized tools for gestural analysis, particularly for applications such as future technology interface development and the computer recognition or synthesis of gesture. The feature-based annotation system has the potential to be compatible with, and could extend, emerging standardized tools as described in recent reviews (for International Standards in Language Engineering see ISLE (2002); Language Resources and Evaluation, LREC (2008) and Language archiving Technology, NEUROGES-ELAN (2009).

Table 5.4 b) G-ABAS three-fold advantages and potential wider applications for interpretation of Child Gesture

Reliability and Validation of Data Analysis

Furthermore, the reliability and validation of the data analysis using the G-ABAS and IPA tools for child gesture were achieved by using seven criteria after Guba and Lincoln (2005) and others, namely: credibility, transferability, dependability, confirmability, informant/respondent validation, prolonged engagement and peer debriefing. These are described, together with a summary of how this was evaluated in relation to the application of the G-ABAS and G-IPA as tools for child gesture research see Table 5.4 c) below. These will be discussed in ensuing chapters.

Criteria for Reliability & Validation of Data Analysis	Applied to G-ABAS & G-IPA tools for child gesture
<i>Credibility</i>	From the perspective of the co-participant child and secondarily the teacher/therapist/clinician
<i>Transferability</i>	Described as the degree to which the results are transferable to other contexts or settings. In this study this involved extending the study to neuro-typical and additional neuro-atypical children and scenarios of interaction, reported in chapter 5 onwards and elsewhere, Panayi, 1998, Panayi et al, 2000. These data would be compatible for annotation with computer based systems.
<i>Dependability</i>	Illustrated by extending the traditional view of validity by emphasising the need to account for every changing context of situated research. This is illustrated by the robustness of the G-ABAS and G- IPA applied to child gesture
<i>Confirmability</i>	Indicates the degree to which the results can be confirmed by others. In this thesis inter-coder reliability was used. All data in this study were video-taped and all original corpus data were coded for agreement (two researchers). 10% of selected exemplars from the six case studies presented in this thesis was coded for agreement by two expert gesture researchers. Agreement was in the region 92%.
<i>Informant/respondent validation</i>	Co-participant children, familiar therapist or teacher provide a level of member checking.
<i>Prolonged engagement</i>	The Child Gesture Corpus is an evolving resource and engagement with children and their gesture repertoires is ongoing.
<i>Peer debriefing</i>	Involved parents, clinicians and therapists involved in the original study and subsequently in peer forums including workshops and conferences.

Table 5.4 c) Criteria for Reliability & Validation of Data Analysis applied to the G-ABAS & IPA tools for child gesture.

5.6 Summary

In chapter 5 I introduced the background to the Gesture-Action-Based-Annotation-System (G-ABAS) and the G-Interpretative Phenomenological Analysis. Both tools and methods are consistent with the theoretical underpinnings of the C-i-A framework. I illustrate how the proposed G-ABAS and G-IPA tools can code for embodied gesture features. Thus, one scheme can be used to code intentional acts of both neuro-typical and neuro-atypical co-participants. These acts may be considered communicative or motor acts present in every day functional settings or related to creative or imaginary contexts. Through interpretation they may reveal potential movement or communicative capacity of the individual. My system has the potential to be used with technology-based systems for the synthesis and recognition of human and more specifically child intentional action embodied in their gestures. The limitations and advantages of G-ABAS and G-IPA are discussed, together with the criteria applied to consider the reliability and validity of such methods. In the ensuing chapters I illustrate how the data analysis framework is applied to the three case studies that examine both corporeal dynamic and corporeal narrative features of child gesture enacted as performance.

Chapter 6 Analyses I

6.1 Corporeal Dynamic and the C-i-A framework

This chapter addresses the second aim of my thesis namely:

Aim 2: To develop qualitative analytical tools for the annotation and interpretation of gesture that can be applied inclusively to both neuro-atypical and neuro-typical young people.

I achieved this by addressing Objective 5: *To examine what gestures reveal about children's corporeal Cognition-in-Action.* I apply G-ABAS annotation and Interpretative Phenomenological Analysis (G-IPA) tools developed and described in chapter 5. In these analyses I present the first level of interpretative analysis that examines corporeal dynamics features of exemplar cerebral palsy gestures from two case studies.

I begin by examining the *Child Gesture Corpus in the context of the G-ABAS and G-IPA* in 6.2. In section 6.3 I present three exemplars from *Case Study 1 Condition A*, an adapted *Charade Game* in sections 6.3.1-6.3.3. In section 6.4 I present the analyses for *Case Study 3 Condition C Manipulation of Artefacts*. In section 6.5 I examine the *potential for scoring, evaluation and validating the G-ABAS and G-IPA tools*. I summarises findings for *Case Study 1 and 3* in section 6.6. In section 6.7 I discuss the *summary findings in the context of the Cognition-in-Action conceptual framework*. In Chapter 7, I present the second and third level of interpretative analysis that examines the complexity that necessarily underlies the enaction of gestures by cerebral palsy children.

6.2 The Child Gesture Corpus

6.2.1 Previous level of manual annotations – A priori knowledge

Neuro-atypical children gesture repertoires were contributed to the Child Gesture Corpus between 1992 and 1994. The neuro-atypical repertoires for Condition A were originally manually annotated. This annotation was limited; it used a three-part *simple movement classification* system for gesture. This included the manual segmentation of the time phase of the salient gesture (*t*). This annotation identified the body part involved and whether the gesture was a *static pose*, *involved a single movement* or a *periodic movement*. Details of the motion capture technology used, annotation, and the computer gesture recognition of a subset of gesture for selected children, are reported in Roy et al. (1994) and Roy (1996).

6.2.2 Action Body Based Annotation and G-IPA

The Three Case Studies

I returned to this corpus to make the selection for the three Case studies 1, 2, and 3, see (Tables 6.1a and b below). In Table 6.1 a) I introduce the Gesture Performance Measure (GPM) and describe it as the number of gestures out of the total possible number attempted for Condition A, B and C. This measure is provided for illustrative purposes only.

Ludic Interaction	Gender	Age	Co-participant code	Case Study	Gesture Performance Measure (GPM) i.e. no. items attempted
Condition A <i>Adapted Charade Game</i>	M	16.9	NAT-CP 9	1	Condition A 100%
Condition B <i>Narrative Co-constructed</i>	M	17.9	NAT-CP 5	2	Condition A 98% (<i>Pretend to fly kite repeated. 'Pretend to barf' not attempted</i>) Condition B 100%
Condition C <i>Manipulation of Artefact</i>	F	10.7	NAT-CP 7	3	Condition A 35.5% (<i>No response discernible by coders for two; 'Show me a triangle' and 'Show me a rainbow, easily fatigued</i>) Condition C 100%

Table 6.1 a) Three case studies are re-summarised in relation to the analysis and interpretation framework. Key: NAT-CP (diagnosis) neuro-atypical cerebral palsy children and adolescents, (S) student, number signifies original designator in Child Gesture Corpus. GPM is the Gesture Performance Measure for the ludic interaction.

All the children selected for the three case studies experience Condition A. For Condition A, GPM indicates the number of items attempted out of 141 for the three co-participants.

The variability in GPM for Condition A supported the development of further ludic scenario conditions. Table 6.1 b) summarises the gesture exemplars presented in Condition A, Condition B and C presented for my thesis. These exemplars have not previously been analysed in detail as they were considered complex interactions beyond the acceptable limits of gesture recognition systems.

Additional interaction data from neuro-atypical children were contributed to the corpus during the period 1995-1996 from the Body Tek Project; see Panayi et al. (1998); for the Today's Stories Project (1998-2000), see Panayi et al (2000). For neuro-typical children during 1997-1998, see Panayi and Roy (2012) and Panayi (2013). These materials do not form part of the submission for this thesis.

Ludic Interaction	Case Study	Exemplar	G-ABAS Phase One Corporeal Dynamics¹	G-ABAS Phase Two Corporeal Narrative²	IPA Level I and II
Condition A <i>Adapted Charade Game</i>	1	<i>'pretend to stroke the cat' play the violin, lasso the steer'</i> from a gesture bank of 141 items	Yes	Yes	Yes
Condition B <i>Narrative Co-constructed</i>	2	<i>'Cowboy comes to Town'</i> Sequence of 41 gesture notions	Yes ³	Yes	Yes
Condition C <i>Manipulation of Artefact</i>	3	<i>Artefact explorations e.g. jelly mould, play food, chocolate mould</i>	Yes	Yes	Yes

Table 6.1 b) Three case studies re-summarised in relation to the gesture exemplar, analysis and interpretation framework read in conjunction with Table 6.1a)

¹ Phase One Corporeal Dynamic Analyses are presented in this Chapter

² Phase Two Corporeal Narrative Analyses are presented in Chapter 7

³ Phase One Corporeal Dynamics are summarised with Corporeal Narrative Analyses in Chapter 7

6.2.3 Phase One G-ABAS Annotation and Level I G-IPA

The tools are applied as follows: Phase One of the action body based annotation system is applied to the examination of corporeal dynamic features. It is guided by the level I G-IPA questions summarised in Box 6.1 a) below.

- *Does the child perform an imaginary (en) action? Does the child perform an enaction with real object, social other?*
- *Where does the child perform the (en) action? Can you describe the child's level of involvement?*
- *Can corporeal dynamics features in motion events be annotated?*
- *Can these corporeal dynamics features be interpreted further? e.g. Are alternative motor performance strategies used? Is there evidence for participatory sense-making?*

Box 6.1 a) Level I G-IPA questions

The segmented exemplars described in the following sections are examined for the following five themes and clusters of features summarized in Box 6.1 b) below.

- **Abstraction of Action [AOA]**
Location in space e.g. egocentric, peripersonal, proximal, distal {5}
Path and Directionality e.g. rotation, inwards, size, curvature {10}
Representation Schema e.g. self, other, functionality, object recognition feature, world interactivity {6}
- **Manipulation of action [MOA]**
Transformation of object e.g. to part of virtual object, to part of real object, additional other manipulation {5}, Transformation of person e.g. self, other {4}
- **Object Representation [OR]**
Imaginary space self/other, e.g. part of other, additional other {5}
Veridical space {5}
- **Emotional Salience [ES] {22}** *e.g. straight line - vital and strong*
- **Interaction Description [ID] {85 +}** *i.e. Movement features such as kinematics (e.g. velocity, speed, deceleration); action geometry (e.g. volume, shape, axis); manner (e.g. effort, bimanual, symmetrical, pose); granularity (e.g. macro/micro environment) and componentiality.*

Box 6.1.b) Themes and clusters

The video montage analyses are presented in a series of figures for each exemplar. The central panel shows the segmented consecutive frames for this enaction. The panel on the left illustrates the word/phrase stimulus cue. The third panel from the left shows the timeline (min, sec). The panel on the right contains the annotation (without codes) for the sequence of video frames. Regions of interest (ROI) are indicated by circles and ellipses. Arrows highlight comments on aspects of corporeal dynamics.

The identification Chart Figure 6.2 summarises how the C-i-A framework underpins the G-ABAS ontology together with levels I and II of the G-IPA. Levels II and III will be discussed in Chapter 7.

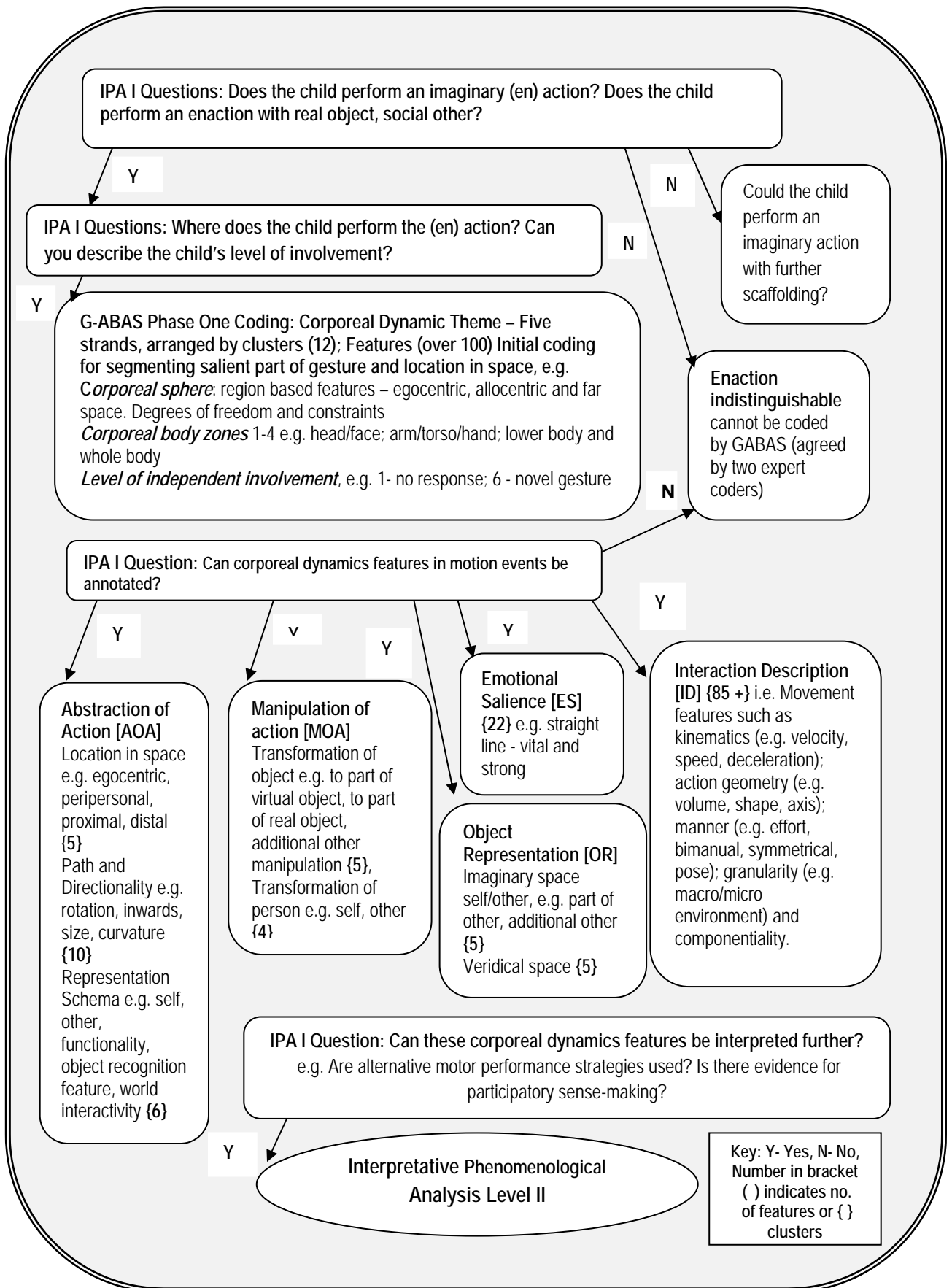


Figure 6.1 Applying Chart 1 G-ABAS ontology and G-IPA level I analyses.

6.3 Phase One Analyses: Condition A Charade Case Study 1

In this section three gestures are analysed. They are presented for the notions of; ‘*pretend to stroke a cat*’ in 6.3.1; ‘*pretend to play the violin*’ in 6.3.2 and for ‘*pretend to lasso that steer*’ in 6.3.3. They are chosen from the adolescent’s repertoire produced during their interaction in Condition A, an adapted charade game with 141 items. This *neuro-atypical adolescent* with severe speech and motor impairment was aged 16.9 years at the time he contributed to the Child Gesture Corpus. He achieved 100% rate of gesture performance (GPM) for the 141 items. His co-participant code identifier is NAT-CP9.

Condition A is a charade game in which a *word or phrase* is presented verbally. The child is asked to enact their performance, e.g. *pretend to play the violin, pretend to be a witch, pretend to hammer, pretend you are hot*. The details for the protocol have been presented in the methods chapter and appendices. Both neuro-atypical and neuro-typical children have contributed to this sub-set of the corpus. Only neuro-atypical exemplars are presented here. A summary list of categories for the charade gesture prompts is provided in Table 6.2a) and a list of the 141 items is provided in Table 6.2b).

18 Notional Gesture Categories Shown with examples	
Actions: <i>Crawl, pull, tear</i>	Musical instruments: <i>piano, drums, violin</i>
Animals: <i>lion, elephant, snake</i>	Objects: <i>cup, necklace, binoculars</i>
Communications: <i>hello, good-bye, wave</i>	Outlines/Shapes: <i>square, triangle, stripes</i>
Descriptions: <i>tall, short, large</i>	People: <i>brother, mum, you, stranger, friend</i>
Events: <i>earthquake, explosion</i>	Senses: <i>hot, cold, bright</i>
Fantasy Characters: <i>dragon, witch</i>	Sport: <i>swimming, fishing</i>
Feelings: <i>sad, happy, disgusted</i>	Travel: <i>train, helicopter</i>
Eating Food: <i>eat hamburger, sip soda</i>	Weather: <i>rain, snow</i>
Movement: <i>faster, slower, delicately</i>	Miscellaneous: <i>steal, drink poison, smoke</i>

Table 6.2 a) Notional gesture Categories Charade Games Illustration of the 18 notional categories with examples. **Table 6.2 b)** below shows an illustrative presentation sequence. Adapted, with permission of Dr. D.M Roy, see (Table 4.4), Roy (1996).

Charade Interaction Scenario: Condition A

Table 6.2 b)

141 Verbal speech prompt alone, randomized by shuffled prompt cards

Illustrative Co-participant Code:

Session: No

Sheet No:

Gesture No	Illustrative presentation sequence of verbal (speech) prompt				
1	Yes	56	Hot	111	Wash Face
2	Good-bye	57	Smell	112	Dig hole
3	Don't know	58	Smooth	113	Crawl
4	hello	59	Cold	114	Pull rope
5	No	60	Soft	115	Asleep
6	Stop	61	Ten pin bowling	116	Take a picture
7	Kiss	62	Cards	117	Handshake
8	Mickey Mouse	63	Fishing	118	Dance
9	Waiter	64	How Big? (fish)	119	Sticky
10	Giant	65	Canoe	120	Knit
11	Open Box	66	Swimming (crawl)	121	Cut Throat
12	Cowboy/horse ride	67	Grand slam	122	Sewing
13	Lasso	68	Make a basket	123	Whistle
14	Baby	69	Tennis	124	Stir
15	Bathroom	70	Throw dice	125	Cup
16	Money	71	Football/ touchdown	126	Type (Typewriter)
17	necklace	72	Rain	127	Climb
18	Umbrella	73	Cold (its)	128	Tear up
19	binoculars	74	Hot (its)	129	Throw
20	Trumpet	75	Sunny	130	Knock
21	Violin	76	Rainbow	131	Saw
22	Guitar	77	Snowflake	132	Bring! Bring! (Phone)
23	piano	78	Lion	133	Catch
24	Saxophone	79	Pig	134	Hammer
25	flute	80	Caterpillar	135	Push
26	drum	81	Butterfly	136	Shave
27	explosion	82	Alligator	137	Ironing
28	earthquake	83	Elephant	138	Dragon
29	pizza	84	Snake	139	Witch
30	Ice cream	85	Fish	140	Ghost
31	yuk	86	Bird	141	Monster
32	sip soda	87	Spider		
33	eat hamburger	88	Beard		
34	Yummy	89	Poison		
35	Triangle	90	Naughty		
36	Mountain	91	Large		
37	Square	92	Tall		
38	circle	93	Short		
39	stripes	94	Milking a Cow		
40	hungry	95	Mosquito		
41	excited	96	Steal		
42	tired	97	Waves (sea)		
43	hug	98	Think		
44	sad	99	Toss a Pancake		
45	love	100	Shampoo		
46	Ouch !	101	Cigar		
47	Angry	102	Balloons		
48	Fast car (racing)	103	Kite		
49	Train/Pull Whistle	104	Patter cake		
50	Helicopter	105	Salute		
51	Car (slow)	106	Press door bell		
52	Airplane	107	Open Door		
53	Listen	108	Close Door		
54	Captured/(surrender)	109	Jump		
55	Bright light	110	Itch		

6.3.1 Neuro-atypical Case Study 1: Exemplar (1) ‘Pretend to stroke the cat’

This section presents the enaction exemplar for the item: ‘Pretend to stroke the cat’.

Application of Phase One G-ABAS Annotation and Level I G-IPA and Findings

Strand 1 shows the corporeal involvement by body part in a given zone. Zone 1 includes the head with associated expressions (facial), vocalizations and speech. Zone 2 includes the arm, hand, wrist, fingers and torso. Zone 3 includes the lower body and Zone 4 captures a whole body gesture. This is summarised in a stylized form that could have future use for therapists/teachers/clinicians/designers (see Figure 6.2).

The themes revealed through these analyses using the G-ABAS and G-IPA are summarised in Figure 6.3 a) a body map diagram for ‘Pretend to stroke the Cat’ together with Table 6.3 a) of descriptors.

The video montage analyses are presented in Figure 6.3 b). The central panel shows the segmented consecutive frames for this enaction. The panel on the left illustrates the word/phrase stimulus cue. The third panel from the left shows the timeline (min, sec). The panel on the right contains the annotation (without codes) for the sequence of video frames. Regions of interest (ROI) are indicated by circles and ellipses. Arrows highlight comments on aspects of corporeal dynamics.

Role Taking

The child takes on the role, i.e. the perspective of the ‘*the self*’, considered a point of view (POV) in the narrative scenarios. In this case the exemplar shows involvement of the whole body. Specific regions of interest (ROI) for such ‘*holistic gesture*’ are marked by circles and spheres. The corporeal level of involvement can be described on a scale of 1-6, where 1 represents no response and 6 a novel gesture.

Strands 2-5 illustrate an *affordances-driven action* within the involvement of a *global or ‘holistic’* gesture enacted for the cue ‘*pretend to stroke the cat*’.

Abstraction of Action

This affordance in turn drives the dynamics of the body co-ordination in terms of the Abstraction of Action. This cluster provides for the annotation of feature patterns that relate to *location*, e.g. the lap region, lower torso region; *posture*, e.g. seated; *path and direction*, left hand moves across midline in the region of the lap (lower torso).

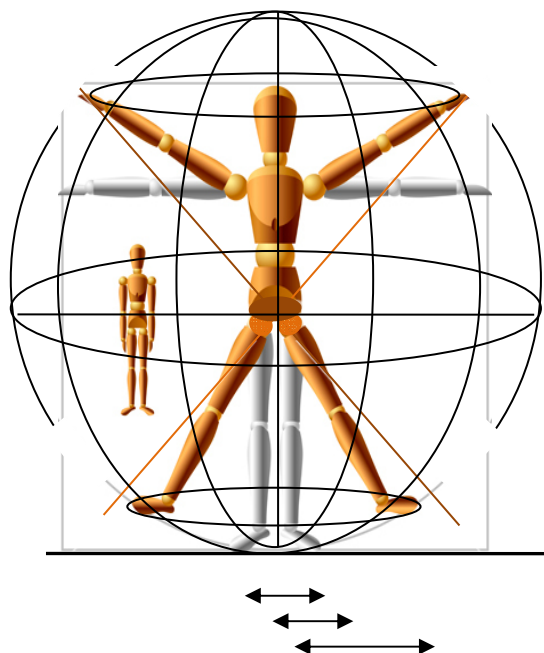


Figure 6.2 Corporeal Gesture Sphere and Body map zones. The co-participant child is centre stage, within the corporeal sphere with schematic body zones illustrated by the 3D frame. The horizontal arrows illustrate peri-personal, allocentric and far space. The co-participant researcher is placed illustratively to the left. The video set-up is not shown, see Chapter 3 Methodology for details. This is shown as an illustration for Condition A alone.

Manipulation of Imaginary Objects

Manipulation of the imaginary objects and parts of the object provide the descriptions to document the involvement of ‘micro-affordances’ related to such objects. Features that can be described include, e.g. *hand shape* adopted for stroking imaginary cat; expressed in this case with a left hand posture where the fist is unclenched. This hand posture is coupled with a finger configuration that allows for micro-gestures *stroking*. The arc denotes the corporeal dynamic of the *stroking* action from right to left across the body in the lap region.

Representations Schema

The next cluster examines *Representation Schema*, for example, the ‘self’ enacting a role expressed in veridical space, in this instance ‘stroking’ the ‘other’, i.e. interaction with an imaginary object the ‘cat’.

Interaction Description

Performance Strategies and Their Implications

A *Performance Strategy* is achieved when a spatial ‘*kinematic profile*’ can be annotated together with an agreed interpretation. For this ‘*holistic*’ gesture body parts are coordinated with postural change whilst the child enacts their role, i.e. the ‘self’ stroking the ‘other’, an imaginary ‘cat’. The form of the enaction is not specified. The adolescent is free to choose the salient features for enaction; in this case however, the initial response initiated an enaction identified as ‘scratch’. Importantly, this was dynamically modified to the *stroke enaction*.

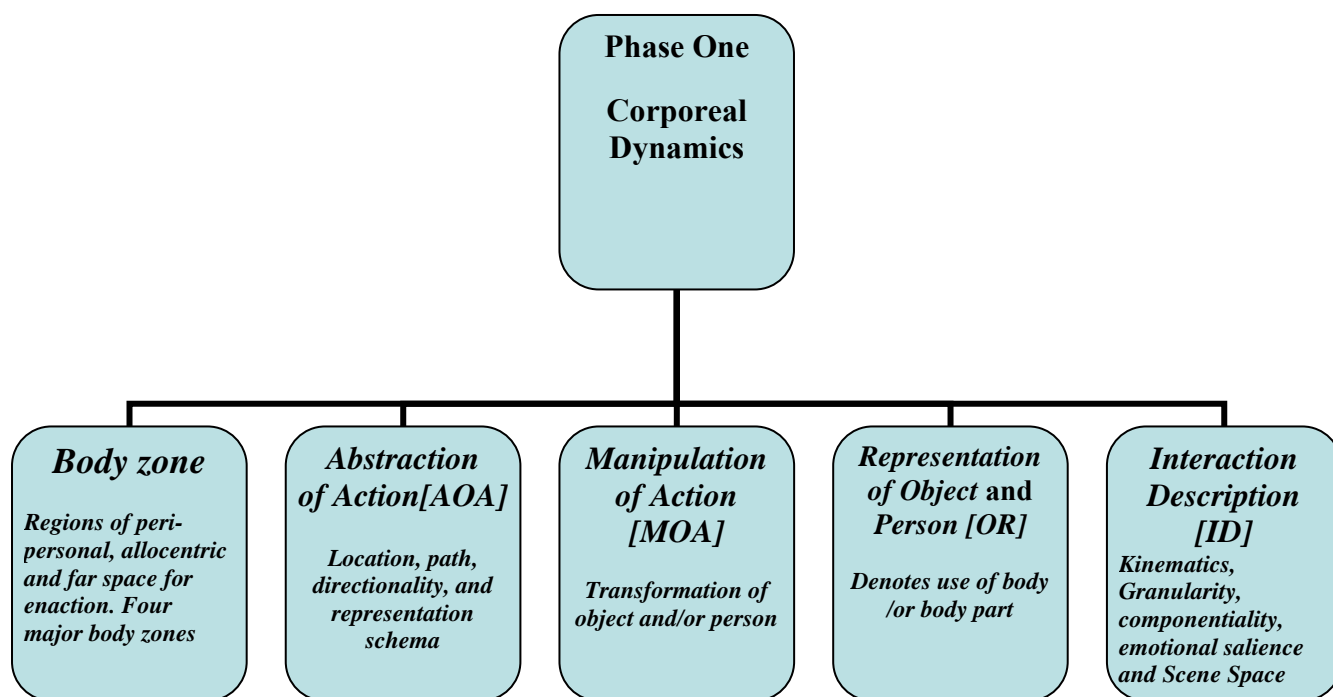


Figure 6.3 a) A Body Map Theme Diagram for ‘Pretend to stroke the Cat’ and Table 6.3 a) of descriptors

Five Strands	Descriptors and subthemes for <i>Pretend to stroke the Cat</i>
Corporeal body zone involvement	The <i>Corporeal Sphere</i> describes the regions of <i>egocentric</i> , <i>allocentric</i> and <i>far space</i> for enaction. This anatomical system is defined by its degrees of freedom and constraints. These constraints may be significant in the case of neuro-atypical children. This gesture is performed in egocentric space All <i>four major body zones</i> are described as initial <i>regions of interest</i> (ROI) they could involve; 1.Head/face; 2. Arm/torso/hand; 3.Lower body and 4, Whole body. A <i>scale</i> is available to describe the level of independent involvement, e.g. 6 - novel gesture.
Abstraction of Action	<i>Location, path and directionality, representation schema</i> , e.g. a choice is made to trace the boundary surface of the imaginary cat and the path taken by the stroking action
Manipulation of Action	Manipulation of stroking action in an appropriate plane <i>Transformation of person</i> , e.g. the self to social other, e.g. the stroking agent with an attempt at stroking hand
Representation of Object & Person	Denotes the use of the <i>body or body part</i> in relation to an imaginary object, e.g. integrity of the surface boundary of the imaginary object (cat) is maintained at an appropriate height
Interaction Description	For example stroking an imaginary object and the ‘self’ as the agent doing the petting of the pet (social other). It can refer to movement features such as: <i>Kinematics</i> , e.g. velocity, speed, deceleration; action geometry, e.g. volume, shape, axis; <i>Manner</i> , e.g. effort, uni-manual with appropriate postural control. <i>Granularity</i> refers to, for example, macro/micro aspects of the environment, e.g. Attempt at hand shape and postural stance with gaze towards imaginary object. <i>Componentiality</i> refers to the elements that may be combined such as: action geometry, kinematic, manner, effort in relation to scene (gesture) space, i.e. Proximal and distal egocentric space enaction. <i>Emotional salience</i> , e.g. facial gesture/expression is consistent with enjoyment during stroking gesture posture and <i>Scene Space</i> other contextual points of interest. Not shown initial modulation of first attempt, verbal prompt misheard as scratch, changed to stroke.


<p>Condition A Adapted Charade game</p> <p>'Pretend to stroke the cat'</p> <p>R: 'not scratch'</p> <p>R: 'That's good'</p>	<p>Segmented Gestural Enaction</p> 	<p>(t) Timeline Min, sec 00, 00</p> <p>00, 03</p> <p>00, 05</p> <p>00, 08</p> <p>00, 11</p>	<p>Corporeal Dynamic Feature Annotation At rest posture, seated</p> <p>Enaction Begins 0.03 Strand 1: Corporeal sphere: region based features – egocentric, allocentric and far space. Degrees of freedom constrained, due to CP motor impairment Corporeal body zones 1-4 e.g. head/face; arm/torso/hand; lower body, whole body Level of independent involvement e.g. 6 - novel gesture Strand 2-5 e.g. Abstraction of Action [AOA] Location in space e.g. egocentric, peripersonal, proximal, distal Path and Directionality e.g. rotation, inwards, size, curvature Open hand, flatter prone in contact with left leg, moving upwards along leg towards waist, in scratch/stroke motion Enaction Ends</p> <p>00.08 2nd Modulated enaction on the fly begins Abstraction of Action [AOA] Change hand shape, point finger, curvature of left hand arm path, across midline in front of and just above knees/lap from right to left (arc) Manipulation of action [MOA]: Repeated stroking action (see text for change of initial attempt) Object Representation [OR] Imaginary cat, inferred by stroking action 'over imaginary cat' contact with leg towards end of gesture, three repeats Emotional Saliency [ES], e.g. head lifts to face forward smile expression Interaction description [ID] kinematics: consistency of velocity, with deceleration at point of contact with imaginary object. Action geometry provided coherence to imagined boundary and surface volume, shape, axis; manner, e.g. effort, uni-manual interaction with 'cat' Enaction repeats, Enaction ends</p>
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Figure 6.3 b) Video Montage and G-ABAS Analysis Condition A Case Study 1 NAT-CP9: 'Pretend to stroke the Cat', manually segmented consecutive frames analysis for corporeal dynamic features and 1st level of IPA Exemplar (1), neuro-atypical child.

The significance of this observation is that it illustrates an example of the adolescent's capacity for *action modulation*, i.e. modifying intentional action of the 'fly'. This holistic enaction couples a complex and often *composite* dynamic profile involving, e.g. *synchrony of acceleration* (to point of contact with imaginary object), *deceleration* (at point of contact with imaginary object) and *rhythmic cycle* of an explicit *stroking* action. Analyses reveal features that include '*boundary and surfaces*', e.g. the cat is inferred by the space left between the left hand and the lap, the finger micro-gestures, together with the dynamic profile, particularly the arc path and directionality of the *stroking* action. The stroking action conveys not only the presence of the cat but also what is described in this case study as a type of '*corporeal kinematic prosody*'.

For comparable discussions on inter-hemispheric specialization of prosody in children, see Wartenburger et al. (2010). Similarly, for a discussion on structural analysis that can be used across images, music and text see Barthes (1977). These extended discussions fall outside the scope of my thesis.

The *consistency* of the enaction is supported by *planes of action* and *orientation of posture* giving a visual *coherence* to the performance. It should be noted, however, that physical interactions in the real world for this adolescent are severely compromised due to the nature of his motor impairment.

This enacted performance of intentional action expressed spatially reveals how the adolescent has the capacity to abstract salient features of action, i.e. Procedural-Gesture-Action-Entities (PAE's). These are combined with features that reveal detailed knowledge of real world experience and affordance, i.e. cat is an object (animals) that can be petted. These fine grained analyses make explicit the intersection of action in veridical space with the *imaginary*. These observations, taken together with the adolescent's latent ability to control intentional action at this level, are significant. These analyses are illustrative of *structure and resource configuration* embodied in the C-i-A framework these aspects are discussed further in subsequent sections.

6.3.2 *Neuro-atypical Case Study 1: Exemplar (2) ‘Pretend to play the violin’*

This section presents the enaction exemplar for the item: ‘*Pretend to play the violin*’.

Application of Phase One G-ABAS Annotation and Level I G-IPA and Findings

The themes revealed through these analyses using the G-ABAS and G-IPA are summarised in Figure 6.3 d), a body map diagram for ‘*Pretend to play the violin*’ together with Table 6.3.b) of descriptors. The video montage analyses are presented in Figure 6.3 c). The central panel shows the segmented consecutive frames for this enaction. The panel on the left illustrates the word/phrase stimulus cue. The third panel from the left shows the timeline (min, sec). The panel on the right contains the annotation (without codes) for the sequence of video frames. Regions of interest (ROI) are indicated by circles and ellipses. Arrows highlight comments on aspects of corporeal dynamics.

Strand 1 shows the corporeal involvement by body part in a given zone. Zone 1 includes the head with associated expressions (facial), vocalizations and speech. Zone 2 includes the arm, hand, wrist, fingers and torso. Zone 3 includes the lower body and Zone 4 captures a whole body gesture.

Role Taking

The adolescent takes on the role, i.e. the perspective of the ‘*violin player*’, revealed by the involvement of the whole body; specific regions of interest (ROI), marked by circles and spheres, focus on different aspects of this ‘*holistic gesture*’.

Strands 2-5 illustrate *affordances-driven action* within the involvement of a *global* gesture to ‘*play the violin*’.

Abstraction of Action

This affordance in turn drives the dynamics of the body co-ordination in terms of the *Abstraction of Action*. This cluster provides for the annotation of feature patterns that relate to *location*, e.g. upper body; *posture*, e.g. seated; *path and direction*, e.g. bimanual co-ordination of arms and hands with head and torso posture. Left hand almost crossing midline, right hand is raised just above head.

Manipulation of Action

The *Manipulation of Action and Object Representation* feature clusters document the involvement of ‘*micro-affordances*’ related to the parts of the violin, held in the right hand. These are inferred, specifically: the chin on the violin chin-rest, violin neck (located in the region of the right hand), strings (in relation to bowing action) the bow (in the left bowing hand, with detail of hand posture and finger configuration). The dotted line denotes the

inferred imaginary bow. Head is facing to the right side with eye gaze attending to playing action. The *violin playing* is described as including the following features: a *precision grip, holding*, i.e. momentarily stationary, this is contrasted with the *rhythmic actions*, i.e. *musicality* and *gestural corporeal prosody*.

Representation Schema

The next cluster examines *Representation Schema*, for example the ‘self’ enacting the role of the *violin player*, expressed in veridical space. The evoked character interacts with distinct parts of the imaginary object, i.e. violin. The presence of this object is inferred by spatial configurations and action.

Interaction Description Performance Strategies and Their Implications

A *Performance Strategy* is achieved with a spatial ‘*kinematic profile*’ annotated together with an agreed interpretation. For this ‘*holistic*’ gesture body parts are co-ordinated with postural change whilst the adolescent enacts his role, i.e. the ‘self’ as a violin player. The form of the enaction has not been specified by the co-participating researcher. The adolescent is free to choose the salient features for enaction. In this case this involves the evocation of the imaginary violin and its associated parts: *chin rest, neck, strings* and the bow.

This holistic enaction couples a complex and often *composite* dynamic profile involving e.g. *synchrony of acceleration* (to point of contact with first imaginary object parts: neck, chin rest, bow), *deceleration* (at point of contact with imaginary object, i.e. violin parts) and *rhythmic cycle* of an explicit *violin playing* action. The playing ‘*enaction*’ conveys not only the *player* but also what is described in this case study as a type of ‘*corporeal kinematic melody and prosody*’. ‘Analyses reveal features that include ‘*boundary and surfaces*, e.g. the bow is inferred by the space left between the hands at shoulder height and their relationship with the imaginary violin. The right hand has a precision grip for the violin neck, and then the left hand changes the grasp for the bowing.

Dynamics of Violin Playing

The dynamic profile, particularly the playing path and the violin player’s motion contribute to the composite nature of the action for the enaction notion. The *consistency* of the enaction is supported by *planes of action, orientation of posture, co-location and the imaginary object to the player*. The interaction description reveals both the visual *coherence* and *consistency* to the interactions embodied and embedded in the performance.

Procedural-Gesture-Action-Entities

This enacted performance of intentional action expressed spatially reveals how the adolescent has the capacity to abstract salient features of action, i.e. Procedural-Gesture-Action-Entities. These are combined with features that reveal detailed knowledge of real world experience and affordance, i.e. this instrument is balanced by the player's chin and held with one hand and the other bows the strings. These fine grained analyses make explicit the intersection of action in veridical space with the *imaginary*. These observations taken together with the adolescents' latent ability to control intentional action at this level is significant. These analyses are illustrative of *structure and resource configuration* embodied in the C-i-A framework which is discussed further in the subsequent chapters.


<p>Condition A Adapted Charade game</p> <p><i>'Pretend to play the violin'</i></p>	<p>Segmented Gestural Enaction</p> 	<p>(t) Timeline Min, sec 00, 00</p> <p>00, 02</p> <p>00, 09</p>	<p>Corporeal Dynamic Annotation</p> <p>At rest posture</p> <p>Enaction Begins 0.02</p> <p>Strand 1: <i>Corporeal sphere:</i> region based features – egocentric, allocentric and far space. Degrees of freedom and constraints. Constraints, due to motor impairment - CP <i>Corporeal body zones</i> 1-4 e.g. head/face; arm/torso/hand; lower body, whole body <i>Level of independent involvement</i> e.g. 6 - novel gesture</p> <p>Strand 2-5: e.g. Abstraction of Action [AOA] Location in space e.g. egocentric, peripersonal, proximal, distal {5/5} Path and Directionality e.g. rotation, inwards, size, curvature {8/10} Representation Schema, e.g. self, other, functionality, object recognition feature, world interactivity {5/6}. Manipulation of action [MOA], Transformation of object e.g. to part of virtual object, Manipulation {5/5}, dotted line. Transformation of person e.g. self, other {1/4} Object Representation [OR] Imaginary space self/other, e.g. part of other – violin chin rest, additional other – bow (dotted straight line {2/5}, Veridical space {4/5}</p> <p>Emotional Salience [ES] - yes [ID] features including: kinematics, e.g. velocity, speed, and deceleration; action geometry, e.g. volume, shape, axis; manner, e.g. effort, bimanual, asymmetrical, pose; granularity, e.g. macro/micro environment and componentiality</p> <p>Enaction repeats, Enaction ends</p>
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Figure 6.3 c) Video Montage and G-ABAS Analysis Condition A Case Study 1 NAT-CP9: 'Pretend to play the violin', manually segmented consecutive frames analysis for corporeal dynamic features and 1st level of IPA Exemplar (2), neuro-atypical child.

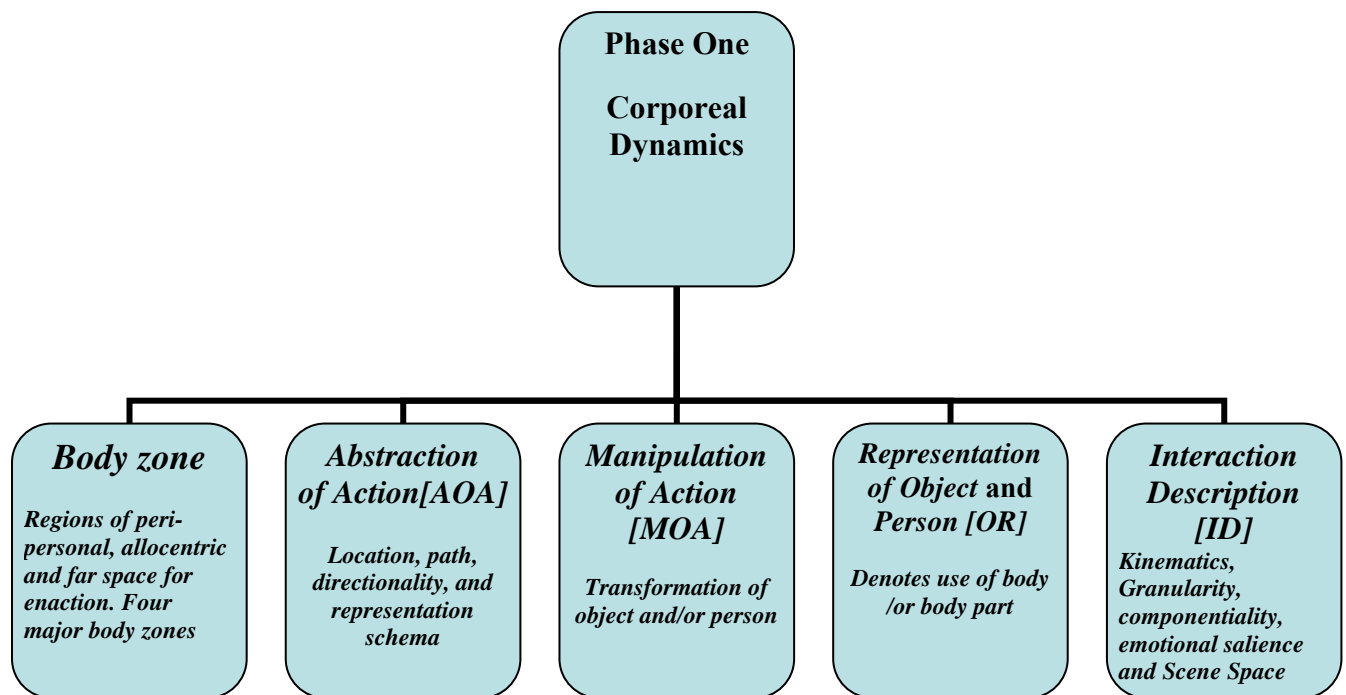


Figure 6.3 d) A Body Map Theme diagram for ‘Pretend to play the violin’ together with Table 6.3 b) of descriptors.

Five Strands	Descriptors and subthemes for ‘Pretend to play the violin’
Corporeal body zone involvement	The <i>Corporeal Sphere</i> describes the regions of <i>egocentric</i> , <i>allocentric</i> and <i>far space</i> for enaction. This anatomical system is defined by its degrees of freedom and constraints. These constraints may be significant in the case of neuro-atypical children. This gesture is performed in egocentric and allocentric space All <i>four major body zones</i> are described as <i>initial regions of interest</i> (ROI), they could involve; 1. Head/face; 2. Arm/torso/hand; 3. lower body and 4, Whole body. The lower body is largely used for stabilization of the enaction <i>A scale</i> is available to describe the level of independent involvement, e.g. 6 - novel gesture.
Abstraction of Action	<i>Location, path and directionality, representation schema</i> , e.g. a choice is made to trace the bowing action across midline with associated body posture of violin player.
Manipulation of Action	Manipulation of right hand to hold the violin; the chin on the violin chin-rest, violin neck (located in the region of the right hand), strings (in relation to bowing action) the bow (in the left bowing hand, with detail of hand posture and finger configuration). <i>Transformation of person</i> , e.g. the self to social other, e.g. the violin player
Representation of Object & Person	‘self’, enacting the role of the <i>violin player</i> , expressed in veridical space. The evoked character interacts with distinct parts of the imaginary object, i.e. violin. The presence of this object is inferred by spatial configurations and action.
Interaction Description	For example playing of imaginary object, violin as a character, self as violin player. It can refer to movement features such as: <i>Kinematics</i> , e.g. velocity, speed, deceleration; action geometry, e.g. volume, shape, axis; <i>Manner</i> , e.g. effort, bi-manual with appropriate postural control. <i>Granularity</i> refers to, for example, macro/micro aspects of the environment, e.g. Attempt at hand shape and postural stance with gaze towards imaginary violin. <i>Componentiality</i> refers to the elements that may be combined such as: action geometry, kinematic, manner, effort in relation to scene (gesture) space, i.e. Proximal and distal egocentric space enaction of playing. <i>Emotional salience</i> e.g. facial gesture/expression is consistent with enjoyment during violin playing gesture and <i>Scene Space</i> used to describe other contextual points of interest. Not shown: initial modulation of playing to faster and slower imaginary tempos.

6.3.3 Neuro-atypical Case Study 1: Exemplar (3) ‘Pretend to lasso that steer’

This section presents the enaction exemplar for the item: ‘Pretend to lasso the steer’.

Application of Phase One G-ABAS Annotation and Level I G-IPA and Findings

The video montage analyses are presented in Figure 6.3 e). The central panel shows the segmented consecutive frames for this enaction. The panel on the left illustrates the word/phrase stimulus cue. The third panel from the left shows the timeline (min, sec). The panel on the right contains the annotation (without codes) for the sequence of video frames. Regions of interest (ROI) are indicated by circles and ellipses. Arrows highlight comments on aspects of corporeal dynamics. The themes revealed through these analyses using the G-ABAS and G-IPA are summarised in Figure 6.3 f) together with Table 6.3 c) of descriptors.

Strand 1 shows the corporeal involvement by body part in a given zone. Zone 1 includes the head with associated expressions (facial), vocalizations and speech. Zone 2 includes the arm, hand, wrist, fingers and torso. Zone 3 includes the lower body and Zone 4 captures a whole body gesture.

Role taking

The child takes on the role, i.e. the perspective of the ‘cowboy’, revealed by the involvement of the whole body; specific regions of interest (ROI), marked by circles and spheres, focus on different aspects of this ‘holistic gesture’.

Strands 2-5 illustrate *affordances-driven action* within the involvement of a *global* gesture to ‘lasso’.

Abstraction of Action

This affordance in turn drives the dynamics of the body co-ordination in terms of the *Abstraction of Action*. This cluster provides for the annotation of feature patterns that relate to *location*, e.g. upper body and far space; *posture*, e.g. seated; *path and direction*, e.g. hand rise to mid torso and one hand rises to above head to the side away from body.


<p>Condition A Adapted Charade game</p> <p><i>'Pretend to lasso the steer'</i></p>	<p>Segmented Gestural Enaction</p> 	<p><i>(t) Timeline</i> <i>Seconds</i></p> <p>00, 00</p> <p>00, 03</p> <p>00, 04</p> <p>00, 05</p> <p>00, 06</p> <p>00, 07</p> <p>00, 08</p>	<p>Corporeal Dynamic Annotation</p> <p>At rest posture</p> <p>0.04 Enaction Begins</p> <p>Strand 1: <i>Corporeal sphere:</i> region based features – egocentric, allocentric and far space. Degrees of freedom and constraints, neuro-typical <i>Corporeal body zones</i> 1-4, e.g. whole body. <i>Level of independent involvement</i> - 6</p> <p>Strand 2-5: e.g. Abstraction of Action [AOA] Location in space is egocentric (peripersonal), proximal and distal features. Path and directionality e.g. rotation of (arm wrist) and size of throwing of lasso curvature. Representation Schema, self as cowgirl, horse, lasso, steer functionality, object recognition feature, world interactivity Manipulation of action [MOA], Transformation of object e.g. to part of virtual object (lasso) Manipulation Transformation of person e.g. self as Cowboy, Left arm raised ready to lasso</p> <p>Object Representation [OR] Imaginary space self/other, e.g. part of other –horse, lasso, additional other – steer (dotted straight line to horse, i.e. distance from eye gaze). Enacted in vertical space Hand posture, attempt at precision grasp of imaginary lasso. Arm raised and circles above head</p> <p>Enaction of lasso swinging repeats Arms come forward with grasp ready to pull back. Head face tilts to right. Bent arm rise with pull back action.</p> <p>Emotional Salience [ES] - yes [ID] features including: kinematics, e.g. velocity, speed, and deceleration; action geometry, e.g. volume, shape, axis; manner, e.g. effort, bimanual, asymmetrical, pose; granularity, e.g. macro/micro environment and componentiality</p> <p>Retraction, pull back of lasso.</p> <p>0.08 Enaction ends</p>
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Figure 6. 3 e) Video Montage and G-ABAS Analysis Condition A Case study 1 NAT-CP9: 'Pretend to lasso the steer', manually segmented consecutive frames analysis for corporeal dynamic features and 1st level of IPA Exemplar (3), neuro-atypical adolescent.

Manipulation of Action and Object Representation

The *Manipulation of Action and Object Representation* features the involvement of ‘*micro-affordances*’ related to four imaginary objects. These are inferred, specifically: the reins (held uni-manually), horse (located under the cowboy), lasso (in the hand) and the steer which is at a distance, head attempting to face forward and eye gaze follows the salient action. The *lasso action* is described as including the following features: a *precision grip, holding*, i.e. momentarily stationary; this is contrasted with the *retraction actions*, i.e. lasso is pulled back with effort suggestive of the weight and counter-action of the steer. The straight arrow denotes the ‘*riding action*’; the wavy arrow denotes the ‘*circular lassoing action*’.

Representation Schema

The next cluster examines *Representation Schemata*, for example the ‘self’, enacting the role of the *cowboy*, expressed in veridical space. The evoked character interacts with *two* imaginary objects, inferred by spatial configurations and action.

Interaction Description

Performance Strategies and Their Implications

A *Performance Strategy* is achieved when a spatial ‘*kinematic profile*’ is annotated together with an agreed interpretation. For this ‘*holistic*’ gesture body parts are co-ordinated with postural change whilst the child enacts his role, i.e. the ‘self’ as cowboy, lassoing the ‘other’, an imaginary ‘*steer*’. The form of the enaction has not been specified by the co-participating researcher. The adolescent is free to choose the salient features for enaction. In this case this involves the evocation of two imaginary objects: *lasso rope* and *a steer*.

This holistic enaction couples a complex and often *composite* dynamic profile involving, e.g. *synchrony of acceleration* (to point of contact with first imaginary object - rope), *deceleration* (at point of contact with imaginary object-steer) and *rhythmic cycle* of an explicit *lassoing* action. The lasso ‘*enaction*’ conveys not only the *lasso of the steer* but also what is described in this case study as a type of ‘*corporeal kinematic prosody*’ for the lasso motions.

Analyses reveal features that include ‘*boundary and surfaces*’, e.g. the rope is inferred by the space left between the hands and their location in relation to the lasso action. The hand attempts a precision grasp for the rope. The dynamic profile particularly the circular swinging path above the head, directionality of the gaze, all contribute to the composite nature of the action for the notion ‘lasso’.

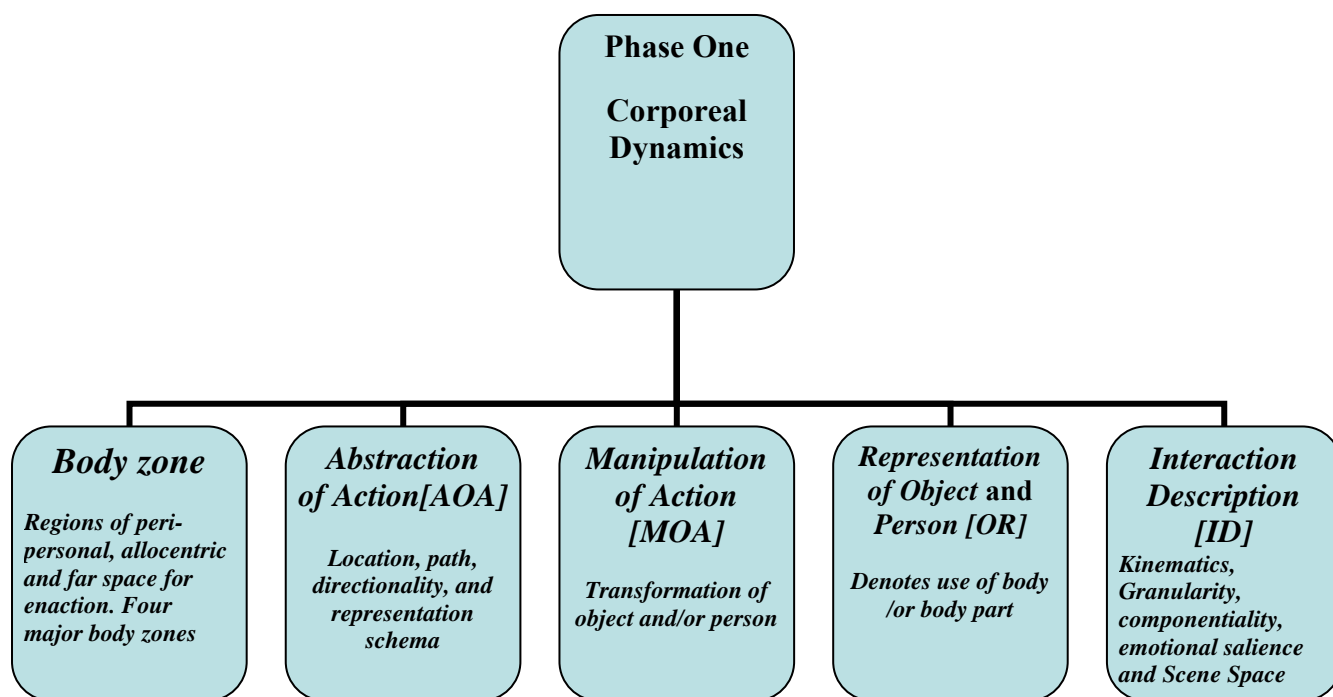


Figure 6.3 f) ‘Pretend to lasso the steer together with Table 6.3.c) of descriptors.

Five Strands	Descriptors and subthemes for ‘Pretend to lasso the steer’
Corporeal body zone involvement	The <i>Corporeal Sphere</i> describes the regions of <i>egocentric</i> , <i>allocentric</i> and <i>far space</i> for enaction. This anatomical system is defined by its degrees of freedom and constraints. These constraints may be significant in the case of neuro-atypical children. This gesture is performed in egocentric, allocentric and far space All <i>four major body zones</i> are described as <i>initial regions of interest</i> (ROI) these could involve; 1.Head/face; 2. Arm/torso/hand; 3.Lower body and 4, Whole body. A <i>scale</i> is available to describe the level of independent involvement, e.g. 6 - novel gesture.
Abstraction of Action	<i>Location, path and directionality, representation schema</i> , e.g. Choices are made to evoke a series of synchronized movement in this enaction, e.g. follow he lasso and riding
Manipulation of Action	Manipulation of right hand to hold the violin; the chin on the violin chin-rest, violin neck (located in the region of the right hand), strings (in relation to bowing action) the bow (in the left bowing hand, with detail of hand posture and finger configuration). <i>Transformation of person</i> , e.g. the self to social other, e.g. the violin player
Representation of Object & Person	‘self’, enacting the role of the <i>violin player</i> , expressed in veridical space. The evoked character interacts with distinct parts of the imaginary object, i.e. violin. The presence of this object is inferred by spatial configurations and action.
Interaction Description	For example playing of imaginary object, violin as a character, self as violin player It can refer to movement features such as: <i>Kinematics</i> , e.g. velocity, speed, deceleration; action geometry, e.g. volume, shape, axis; <i>Manner</i> , e.g. effort, bi-manual with appropriate postural control. <i>Granularity</i> refers to, for example, macro/micro aspects of the environment, e.g. Attempt at hand shape and postural stance with gaze towards imaginary violin. <i>Componentiality</i> refers to the elements that may be combined such as: action geometry, kinematic, manner, effort in relation to scene (gesture) space, i.e. Proximal and distal egocentric space enaction of playing. <i>Emotional salience</i> e.g. facial gesture/expression is consistent with enjoyment during violin playing gesture and <i>Scene Space</i> describe other contextual points of interest. Not shown: initial modulation of playing to faster and slower imaginary tempos.

The *consistency* of the enaction is supported by *planes of action, orientation of posture, co-location and transformation of the imaginary objects*. The interaction description reveals both the visual *coherence* and *consistency* to the interactions embodied and embedded in the performance. This enacted performance of intentional action expressed spatially reveals how the adolescent has the capacity to abstract salient features of action, i.e. Procedural-Gesture-Action-Entities. These are combined with features that reveal detailed knowledge of real world experience and affordance, i.e. cowboys are able to capture (animals) with a lasso. These fine-grained analyses make explicit the intersection of action in veridical space with the *imaginary*. This is illustrative of *structure and resource configuration* embodied in the C-i-A framework and is discussed further in subsequent sections.

6. 4 Phase One Analyses: Condition C Manipulation of Artefacts







6.4.1 Neuro-atypical Case Study 3: Exemplar (1) Jelly Mould

In this section an exemplar is presented from the repertoire of Case Study 3, a neuro-atypical female child with severe speech and motor impairment. She was 10.7 years at the time she contributed to the Child Gesture Corpus. She attended a special school in the USA. Her co-participant identifier code is NAT-CP7.

She had previously found enactions from Condition A, the adapted charade games, difficult. This interaction was devised to explore her micro-gesture capacity. The session provides opportunity for children to participate in interface design for future technology.

Condition C focuses on the manipulation of artefacts. In this instance the artefact is placed flat on the child’s communication tray. The child is given an initial prompt for the exploration, after which they are free to initiate intentional movements. The interaction is with the co-participating researcher/designer. A second co-designer/researcher and therapist are also present. Details for the protocol have been presented in the methods chapter and appendices. Both neuro-atypical and neuro-typical children have contributed to this sub-set of the corpus. Only neuro-atypical exemplars are presented here.

The stimulus tool uses artefacts to elicit micro-gestures in the veridical world. In the region of 20 real artefacts are used as stimulus probes to explore this manipulation capacity. These include: *jelly and chocolate moulds, pieces of bubble pack, play food, e.g. chocolate doughnut and pizza, prickly orange ball, and novelty pens and an assortment of other artefacts such as beads and balls of different sizes and texture* (not shown). Six illustrative types of artefacts are shown in Box 6.2. The exemplar shown in this video montage analysis is Artefacts No 1 ‘jelly moulds’.

Artefact No: 1 Jelly mould	Artefact No: 2 Bubble-pack piece	Artefact No: 3 Chocolate doughnut	Artefact No: 4 Orange ball	Artefact No:5 Play pizza	Artefact No: 6 Chocolate mould
					

Box 6.2 Illustrative Artefact Exemplars for Condition C Manipulation of Artefacts

Acknowledgement is given when a gesture is achieved even after significant effort, as is the case in the exemplar depicted.

6.4.2 Application of Phase One G-ABAS Annotation, Level I and II G-IPA and Findings

Corporeal Dynamic Features are revealed through fine-grain analysis using Phase One of the G-ABAS. These are summarised for this manipulation exemplar in Figure 6.4 a) using video montage. The panel on the right provides an indication of the verbal and visual interaction prompts. The segmented *gesture is* shown in the central panel together with the artefact interaction. The timeline is shown in the panel to the right of the segmented gesture video frames. The right hand panel illustrates the application of simplified corporeal dynamic and narrative annotation. Regions of interest (ROI) are indicated by circles and ellipses. Arrows highlight comments on aspects of corporeal dynamics (unbroken lines). These data are summarised in Figure 6.4 b) which shows A Body Map Diagram and Table 6.4 of descriptors.

Exemplars from this condition are discussed again in terms of corporeal narrative gesture features in Chapter 7.


<p>Condition C Manipulation Artefacts ‘R: you could press, push bits of it’</p> <p>Encouragements from therapist ‘...go on’</p>	<p>Segmented Gestural Enaction</p> 	<p>(t) Timeline Seconds</p> <p>00,25</p> <p>00, 38</p> <p>00, 40</p> <p>00, 42-</p> <p>00, 48-</p> <p>00, 52</p>	<p>Phase One Corporeal Dynamic Annotation</p> <p>At rest posture, attentive, prior to enaction</p> <p>0.38 Enaction Begins Strand 1: Corporeal sphere: region based features – egocentric and far - space. Degrees of freedom: constraints due to motor impairment - CP Corporeal body zones 1-4 e.g. head/face; arm/torso/hand; lower body. Ellipses and circles Level of independent involvement e.g. 6 - novel enaction Strand 2-: Abstraction of Action [AOA] Location in space e.g. egocentric, torso postural adjustments, proximal, Path and Directionality e.g. rotation, inwards, size, curvature Left hand, clenched fist opens partially, fingers extend. Attempted precision grasp, cupped hand, 0.40 - 0.42 Representation Schema, e.g. self, object recognition feature, world interactivity 0.42 – 48 Manipulation of action [MOA] Micro- movement gestures, raised fingers adjustment to grasp, fingers tucked under, and stabilising index finger. Palm co-ordination to move artefact forward independently Emotional Saliency [ES] - yes [ID] Design session</p> <p>Loss of contact by the Hand/fingers with artefact</p> <p>Enaction ends Interaction continues with researcher</p>
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Figure 6.4 a) Video Montage and G-ABAS Analysis. Condition C: Manipulation of Artefacts. Case Study 3 NAT-CP7 *Jelly Mould Exemplar*. Manually segmented Consecutive frames for corporeal dynamic, narrative features, 1st and 2nd level of IPA analyses. Arrows indicate significant changes in gaze either towards other as artefact or social other

6.4.3 Interpretative Findings

Abstractions of Action

This child's corporeal dynamics range demonstrated *abstractions of action* by executing a combination of gross (target) movements, i.e. towards the artefact (proximal egocentric space) with postural adjustments. In addition she made attempts towards a precision grasp/cupped hand. However, these movements were compromised by the nature of her hand contractures. She showed ability for limited rotation and inward movements.

Manipulation of Artefact and Action - Micro-Gestures

The enaction illustrates perseverance and the manipulations of action are significant. This co-participant had severely compromised movement of the hand and torso. Her GPM for Condition A was lower than the other case study co-participants. The interaction scenario was motivated by a future technology design brief to investigate the potential for encouraging and harnessing *micro-gestures*. Micro-gestures are described as smaller finger and hand movements that could be exploited for interface design. This design brief does not form part of this thesis. These micro-gestures are revealed as a result of co-ordination of the upper body-torso, arms and hands. Only one hand is involved in the interaction with this artefact; the head and torso are typically used for stabilisation. The role of eye gaze was not investigated in these analyses. Importantly this interaction scenario demonstrated how corporeal action can be used in a non-formal exploratory context. For example, she attempted to adapt her hand shape for size and curvature of object, e.g. raised fingers adjustment to grasp, fingers tucked under, and stabilising index finger. She used a palm co-ordination strategy to move artefact forward independently.

The co-participant was able to score high for novel actions (6) since her movements and level of engagement had not previously been seen. This was verified by a familiar therapist who was co-present.

Representation Schema and Improvisation

Representation schema was inferred by the use of appropriate 'play affordances' with, e.g. play food objects; push, prod stroke traverse artefact surfaces. The ability to engage with an imaginary object created through improvisation was also evident, e.g. when difficulty was experienced by the co-participant in traversing a chocolate (Hershey Kisses) mould, it was suggested that her hand may be a spider. The participant was told that her co-participating researcher was scared of spiders. This provided the opportunity for improvised movements which revealed her comprehension of the notion 'scared'/'fear of spiders'.

Interaction Description
Performance Strategies and Their Implications

A *Performance Strategy* is achieved when a spatial '*kinematic profile*' can be annotated together with an agreed interpretation. For this '*holistic*' gesture body parts are co-ordinated with postural change whilst the child enacts their role, i.e. the 'self' as player interacting with veridical others as social others and/or objects. The form of the enaction was in this case guided by the co-participating researcher as the nature of the interaction was a design session.

The child is free to select what is salient for the manipulations once the prompt is offered. The co-participating child is aware of the purpose of the interaction. The child takes the role of a co-participating designer as they interact with veridical artefacts including, e.g., jelly mould, bubble pack, toy donut, chicken pieces, fries, pizza, beads, plastic peaked mould and playdoh. Intentional actions are produced in response to verbal visual prompts that are afforded by the artefact. Corporeal co-ordination including postural change is observed whilst the artefacts are explored and manipulated.

Analyses reveal features that include responses to '*boundary and surfaces*', e.g. the texture and shape of the artefact. The hand attempts a precision grasp for affordances of picking up objects. The dynamic profile is restricted due to the physical hand constraints and contractures. The interaction description reveals both the visual *coherence* and *consistency* to the interactions embodied and embedded in the exploration and improvisation performances. These are combined with features that reveal detailed knowledge of real world experience and affordance, e.g. eating chips, chicken and pizza. These fine grained analyses make explicit the intersection of action in gesture space with the physically present *artefacts*.

In summary these enacted explorations of intentional action reveal how the child has the latent capacity to abstract salient features of action, i.e. Procedural-Gesture-Action-Entities. The narrative features expressed corporeally are discussed in Chapter 7. This is illustrative of *structure and resource configuration* embodied in the C-i-A framework and is discussed further in subsequent sections.

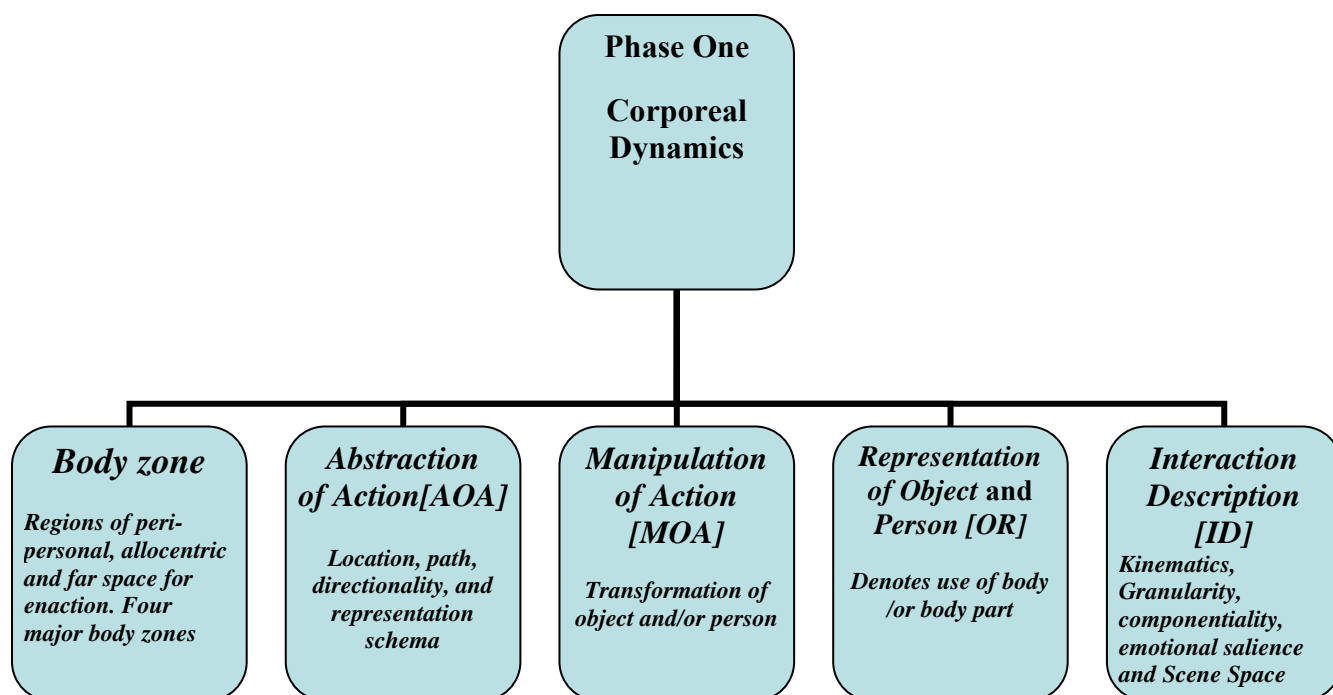


Figure 6.4 b) A Body Map Diagram and Table 6.4 of descriptors.

Five Strands	Descriptors and subthemes for ‘Pretend to eat, play, explore’
Corporeal body zone involvement	The <i>Corporeal Sphere</i> describes the regions of <i>egocentric</i> , <i>allocentric</i> and <i>far space</i> for enaction. This anatomical system is defined by its degrees of freedom and constraints. These constraints may be significant in the case of neuro-atypical children. This gesture is performed in egocentric, allocentric and far space All <i>four major body zones</i> are described as <i>initial regions of interest</i> (ROI) these could involve; 1.Head/face; 2. Arm/torso/hand; (3.Lower body mainly used for stabilization) A <i>scale</i> is available to describe the level of independent involvement, e.g. 6 - novel gesture.
Abstraction of Action	<i>Location, path and directionality, representation schema</i> , e.g. Choices are made to evoke a series of synchronized movement in this enaction, e.g., pretend play and micro-movement exploration. These were executed as a combination of gross (target) movements, i.e. towards the artefact (proximal egocentric space) with postural adjustments. Attempts were made towards a precision grasp/cupped hand.
Manipulation of Action	Micro-gestures are described as smaller finger and hand movements that could be exploited for interface design. These micro movements are revealed as a result of co-ordination of the upper body-torso, arms and hands. Only one hand is involved in the interaction with this artefact; the head and torso are typically used for stabilisation. The role of eye gaze was not investigated in these analyses.
Representation of Object & Person	‘self’, enacting the role of the <i>player</i> , expressed in veridical space. The evoked character interacts with social other researcher. The presence of the veridical object is explored.
Interaction Description	Jelly Mould Exploration ; sustained exploration attempting to use micro-gestures across different textures and surfaces. These included attempts at improvised play (see chapter 7). Variation in range of attempted movements. Features included changes in speed, ability to slow movement and responds to changes in shape; e.g. peaks and valley of chocolate mould, jelly mould. Manner: was largely unimanual for manipulations, body involved in postural control. The Granularity of the interaction was focused in peripersonal space with some attempts at allocentric interaction with researcher, e.g. Spider improvisation with chocolate mould exemplar . Componential movements with clear transitions, i.e. proximal and distal egocentric space enaction of playing. Emotional salience, e.g. facial expression on enjoyment in the play was documented. Scene Space features are explored in Chapter 7

6.5 G-ABAS and G-IPA Potential for Scoring, Evaluation and Validation

6.5.1 Scoring

The G-ABAS and the G-IPA tools have the capacity for annotation features and interpretative findings to be scored, i.e. number present for each pattern cluster per gesture. These could in turn be used for quantitative studies. However, scoring is not the focus of my thesis. These findings and descriptors do contribute to a Spatial Kinaesthetic Intelligence Profile (SKIP). This instrument is under development as part of the future work of this thesis and is linked to the third aim of the thesis. It is discussed and illustrated in Chapter 7.

6.5.2 Evaluation and Validity Cohen's Kappa

Cohen's Kappa calculations have been used to validate the annotation between two expert researchers. These range between 92 and 95% across the ludic conditions. Such evidence, together with the interaction paradigm, provides an inclusive method for constructing the validity of gestural ability of both neuro-atypical and neuro-typical children that goes beyond conventional gesture notation schemes and linguistically driven models of gesture. The author suggests firstly, that the gesture systems of children with cerebral palsy may be driven towards emulation rather than imitation through *adaptive association*, and secondly that selected feature analysis can begin to reveal potential mechanisms that underlie both *spatial and kinaesthetic cognition in action*.

Mention should be made of the concerns that still exist with respect to the granularity of annotation categories. For a discussion of these issues that arise when using a favoured annotation tool (ANVIL), see a study for classification of simple head and face gestures by Navarretta and Paggio (2010), Carletta (2007), cited Panayi (2010). In Chapter 3 I have summarised issues that deal with both stimuli and data structure validation.

It should be noted that to date there is no established coding/annotation system that gives either the granularity or extent of feature coding for gesture that can be used for both neuro-atypical and neuro-typical child gesture. However, despite GABAS being a relatively new instrument, competency reliability for two expert coders (1 researcher and 1 co-researcher) of over 80% was achieved on selected sampling (10%); this is beyond that commonly used as acceptable inter-rater reliability (IRR) for observational coding from video, especially for new instruments where it is closer to >70%.

The proportion of overall agreement (Po) is the proportion of cases for which rater 1(A) and 2(B) agree is displayed in Box 6.3 a) and b) below.

$$Po = \frac{a+d}{a+b+c+d} = \frac{a+d}{N}$$

$$Po = \frac{133+7}{133+7+6+7} = 0.915$$

Acceptable coefficient is value above 0.75

Box 6.3a) Cohen's Kappa

However, this Cohen Kappa coefficient lacks information that may be useful in terms of distinguishing between agreement on positive rating and agreement on negative ratings.

Total Gestures No=141 Condition Charade Game		B	
		Yes	No
A	Yes	133 Agreed by both	7
A	No	6	7 no gesture/rejected by both

Box 6.3 b) Cohen Kappa for Condition A, illustrated for one session, case study NAT-CP 9.

6.6 Corporeal Dynamic Feature Pattern Analyses for Case Study 1 and 3

Micro examination and analysis of the exemplar gestures of children reveal their *procedural knowledge of action*, as explicitly expressed through what I have termed Procedural-Gesture Action Entities (P-GAE). These entities are expressed both through a child's ability to *abstract* action features and also as their ability to *modulate* such action dynamics on *the fly*. These co-ordinated enacted performances reveal a complex understanding of Cognition-in-Action that incorporates a detailed knowledge of embodied and exbodied human-artefact interaction and manipulation. However, the neuro-atypical profile means that as a biological system there may be initial constraints operating at both the physiological and cognitive level. An investigation of these constraints is beyond the scope of my thesis. The expression of these latent abilities does, however, have significant implications for the third aim of the thesis.

Summary findings of Corporeal Dynamic Features found in the exemplars presented for the Case Study 1 and 3 are shown in simplified form in Table 6.5. They are illustrated in terms of the presence of Procedural Gesture Action Entities (P-GAE's). The G-ABAS themes are shown in the left hand column.

Corporeal Dynamic Feature Analyses		
G-ABAS Themes and G-IPA level I and II	<i>Case Study</i>	
	1	3
	<i>Procedural Gesture Action Entities</i>	
Abstraction of Action	+	+
Representation Schema	+	+
Manipulation of Action	+	+
Object Representation	+	N/A
Emotional Saliency	+	+
Level of Involvement <i>Including novel gesture</i>	6	6
<i>Modulation on the fly</i>	+	+

Table 6.5 Corporeal Dynamic Features Annotated with G-ABAS guided by Interpretative Phenomenological Analysis (G-IPA) level I and II questions. Key [+] indicates examples found [-] no exemplar found or N/A, see chapter 7 for exemplar.

These young people show that they have the capacity to perform imaginary enaction within this social ludic interaction. All performances are *near-spontaneous* within this scenario. They are free to choose the corporeal dynamic features that are *salient*, e.g. manner, path, form and detail of the enaction features; the exception being in the design session where veridical objects are provided. There is some level of verbal context provided with suggestions for movement and imitation.

Gestural Prosody

The enactions are typically achieved by the coupling of a complex and often *composite* dynamic kinematic profile involving, e.g. *synchrony of acceleration, deceleration and rhythm of an explicit action*. More specifically, the head, torso, arms and hand embody and take up position and execute dynamic action in relation to imaginary object and parts of object. These dynamic actions can be seen to convey a *rhythmic consistency* with, for example, the stroking of the soft fur of a cat, riding a horse or playing a violin or play/exploring previously unseen artefact. The enactions evoke performance with either single, multiple imaginary or real objects. Analyses of features also convey information with regard to ‘*boundary and surfaces*’, e.g. the imaginary *cat*, are inferred, as are the parts the *violin (chin rest, neck and scroll), bow and lasso*.

Thus the co-ordination of holistic body dynamics quality is described globally as a ‘*corporeal kinematic gestural prosody*’. This gestural prosody incorporates planes of action and orientation of posture. The interaction descriptions reveal both the visual *coherence* and *consistency* in the interactions embodied and embedded in the performance. These in turn reveal aspects of spatial cognition that relate to the corporeal dynamic of enaction.

These affordance driven interactions are revealed through fine grained analysis. They relate to the nature of the social interaction and/or the functionality of artefacts. They may become manifest in, e.g. the nature of the *grasp*, *reaching* or *touching* actions associated with objects, size and surface. This is seen in the examples for precision grasps for: ‘*reins*’, ‘*chin on violin chin rest*’, and holding of ‘*bow*’, ‘*lasso rope*’ or the *stroking* of an ‘*imaginary cat*’ and play with jelly mould or play food.

However, it is clearly evident that the majority of these experiences may not have been experienced directly by these young people. These forms of world knowledge are often outside the immediate moment-to-moment scenario. Together with the observation that the neuro-atypical co-participants have the capacity to modulate their enaction on the *fly*, these observations have significant implications for the third aim of this thesis and are discussed in ensuing chapters.

I would argue that these findings carry implications for clinical practice in e.g. diagnosis and monitoring of the physical capabilities of young people with severe speech and motor impairment. This is discussed further in Chapters 7 and 8.

6.7 Summary of Interpretative Findings

Corporeal Dynamics Feature Analyses and the C-i-A Framework

In this chapter I have provided qualitative evidence that intentionality of the action embodied in child gesture enaction can be revealed by applying the G-ABAS, guided by IPA questions. These findings are supported by a fine grained and layered ontology for specific feature pattern analyses. The interpretation of these findings instantiated aspects of children's Cognition-in-Action. They are illustrative of *structure and resource configuration* within the Cognition-in-Action framework.

These analyses have shown that both global (macro) and micro affordances can be coupled with human capacity to generate imagery for simulated (covert) gesture {GA-SA} and executed (overt) gestural action {GA-EA}. These capacities provide the foundation for corporeal enaction. These exemplars illustrate how these neuro-atypical young people have the potential to be able to compensate for their cerebral palsy at some level. They are able to perform controlled complex, asymmetrical/ symmetrical and bimanual gestures. This latent ability is present despite a highly variable movement profile, exclusitory attitudes and severely compromised opportunities for physical interaction with the real (veridical) world.

The C-i-A framework suggests that the presence of these features can be used to infer the integrated, highly interconnected and adaptive nature of the system for neuro-typical child gesture. Gestural narratives in particular provide a rich and more complex environment for the exploration of such emergent action. Exemplars are presented in Chapter 7 in the context of level III G-IPA analyses. The implications for the postulated supramodal neuro-dynamics and integration within the C-i-A framework are summarised in Chapter 8.

Finally, the analyses in this chapter show how these illustrative findings validate patterns revealed as corporeal dynamic features in child gesture. These data provide evidence in support of the second aim of the thesis.

Chapter 7 Analyses II

7.1 Corporeal Narrative Features and the C-i-A Framework

This chapter addresses the second and third aims of my thesis namely:

Aim 2: To develop qualitative analytical tools for the annotation and interpretation of gesture that can be applied inclusively to both neuro-atypical and neuro-typical young people and Aim 3: To consider the conceptual framework in terms of its theoretical implications and practical applications.

I apply *Phase Two of the G-ABAS and the second and third levels of the G-IPA* in section 7.2 to selected exemplars from *Case Study 2: Condition B Co-Constructed Narrative* in section 7.3 and *Case Study 3: Condition C Manipulation of Artefacts* in 7.4. My findings provided evidence in support of Objective 5 which aims to *examine what gestures reveal about children's corporeal Cognition-in-Action* in 7.5. In section 7.6 I illustrate the *potential for applying the G-ABAS and G-IPA tools in pedagogic, clinical and design settings through the use of the Spatial Kinaesthetic Interaction and Intelligence Profile (SKIP)*. I discuss issues of scoring, evaluation and validity. This work addresses Objective 6 which aims to identify the practical utility of G-ABAS and G-IPA. The chapter ends with a *summary* of my findings and discusses these in the context of the Cognition-in-Action conceptual framework in 7.7.

7.2 Phase Two G-ABAS Analyses Corporeal Narrative Features

Phase Two of the G-ABAS is applied to the examination of corporeal narrative features. It is guided by the II and III level G-IPA questions stated in Box 7.1 a) below.

- ❖ *What types of enaction strategies are expressed spatially?*
- ❖ *What does spatially expressed enaction reveal about corporeal cognition? and*
- ❖ *What evidence is there for participatory-sense-making?*

Box 7.1 a) Level II and III G-IPA questions

The segmented exemplars described in the following sections are examined for the following five clusters of features described in Box 7.1.b).

- ❖ *Source of Narrative Knowledge [SNK], e.g. imagination, ephemeral, binding*
- ❖ *Scale of Narrative [SN], e.g. 1-6*
- ❖ *Narrative Gesture Space [NGS], e.g. point of view, grounded, story world, enacted*
- ❖ *Manipulation of Abstract Thoughts [MAT], e.g. mathematical, scientific and creative*
- ❖ *Narrative Emotional Space [NES], e.g. contexts including use of ‘stage space’ linked with corporeal dynamics features.*

Box 7.1b) Phase Two Themes and clusters

The annotation and interpretation are supported by the guide schematised in Figure 7.1. Identification Chart No. 2 summarizes G-ABAS ontology and the three levels of IPA. It can be read in conjunction with Chart 1 in Chapter 6 section 6.1.

In Table 7.1 I summarise the gesture exemplars presented in Condition B and C presented for my thesis. These exemplars have not previously been analysed in detail as they were considered complex interactions beyond the acceptable limits of existing computer gesture recognition systems.

Ludic Interaction	Case Study	Exemplar	G-ABAS Phase One Corporeal Dynamics	G-ABAS Phase Two Corporeal Narrative	IPA Level II and III
Condition B Narrative Co-constructed	2	<i>‘Cowboy comes to Town’</i> Sequence of 41 gesture notions	Yes	Yes	Yes
Condition C Manipulation of Artefact	3	<i>Artefact explorations e.g. play food</i>	Yes	Yes	Yes

Table 7.1 Case Study 2 and 3 gesture exemplars summarized in terms of the stage of analysis and interpretation framework can be read in conjunction with Table 6.1a).

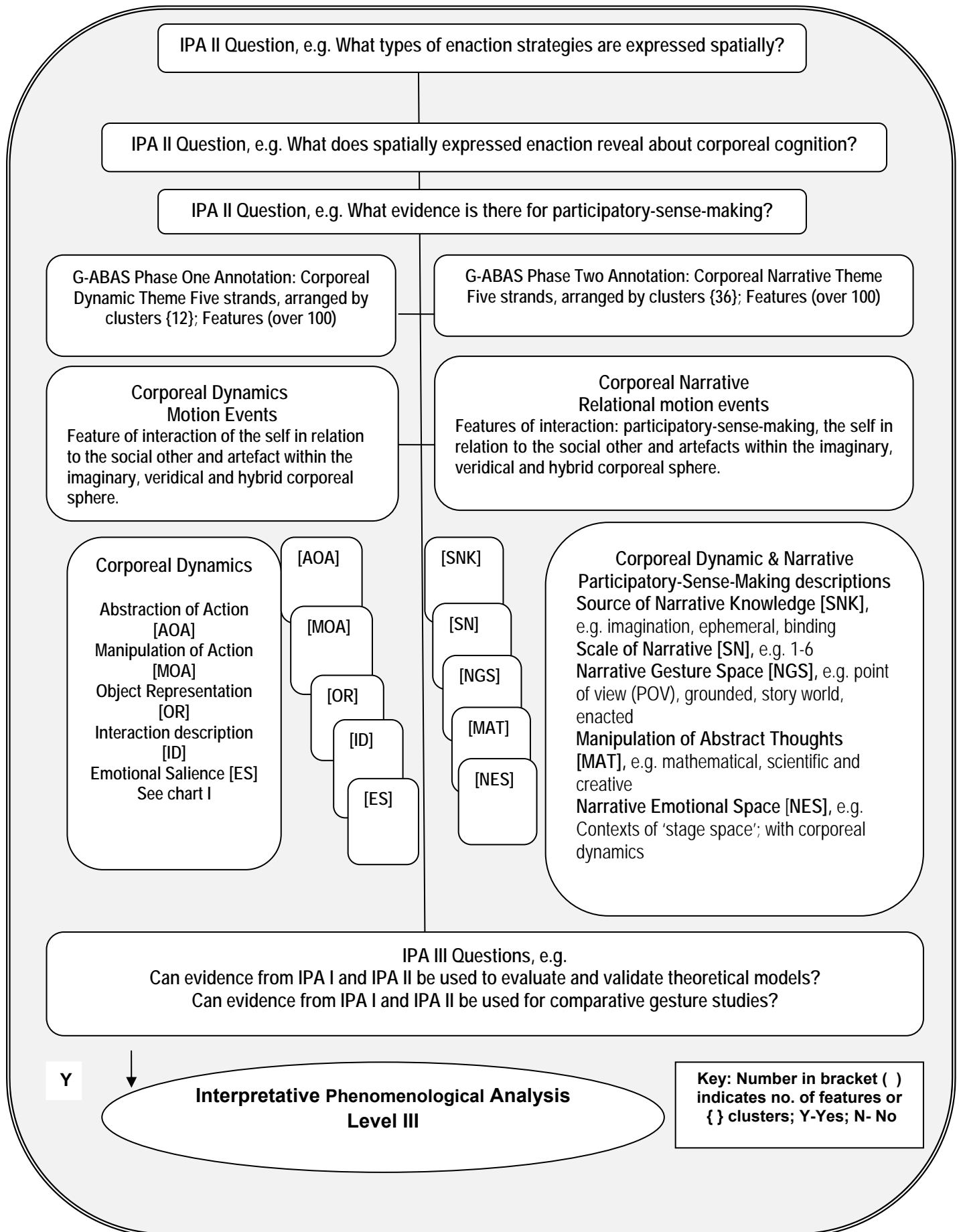


Figure 7.1 Identification Chart 2 summarizes G-ABAS ontology and three levels of G-IPA.

7.3 Phase Two Analyses: Condition B Co-Constructed Narrative

7.3.1 *Neuro-atypical Case Study 2: ‘Cowboy comes to town’*

In *Case Study 2*, gestures are enacted by a *neuro-atypical* adolescent male with severe speech and motor impairment due to cerebral palsy (CP). He was aged 17.9 years when he contributed to the Child Gesture Corpus. He attended a special school in the USA. His co-participant identifier code is NAT-CP5.

Condition B described a co-constructed narrative (CCN) interaction, ‘*Cowboy comes to town*’. The adolescent provides a corporeal narrative stream interactively to the spoken narrative presented by the co-participant (researcher); see chapter 4 for details of the methodology and protocol. The form of the enaction is not specified. The adolescent is free to choose salient features for enaction. The first holistic gestural notion, the ‘*Cowboy rides into town*’, is presented in the section that follows. Table 7.2 shows an illustration of 41 isolated Co-Constructed Narrative gestures enacted during the ensuing session. The session lasted for approximately 30 minutes.

7.3.2 *Application of Phase Two G-ABAS Annotation and Level II G-IPA and Findings*

This analysis examines the video for features of corporeal narrative which are described as relational events. A simplified ontology for Phase Two of the G-ABAS is provided. For any interaction they can reveal participatory-sense-making abilities in relation to self (protagonist), social other and the other as artefact. These others may be present in the real world, the imaginary or hybrid scenarios. Details of the annotation system are provided in Chapter 5. Codes are provided in the appendices.

Figures 7.2 a)-c) show the analyses presented as an annotated *video montage*. The *narrative stream* is provided by the researcher; see annotations right hand box. The *gesture stream* is made up of selected segmented consecutive video frames, presented in the central panel. The timeline for the first 1.03 minutes of the interaction is shown in the panel to the right of the gesture stream video frames. The last panel on the right contains the corporeal dynamic and corporeal narrative annotation (without codes) for the sequence of video frames. Regions of interest (ROI) are indicated by circles and ellipses. Arrows highlight comments on aspects of corporeal dynamics and of corporeal narrative interest. This extract of the performance is particularly significant as it illustrates the young person’s *perseverance*, *level of manipulation* and the apparent attempts to correct the enaction, i.e. *modify on the fly*. Acknowledgement is given when a gesture is achieved. In Table 7.4 a matrix summarizes the Phase Two Corporeal Narrative features in relation to the G-IPA level II questions.

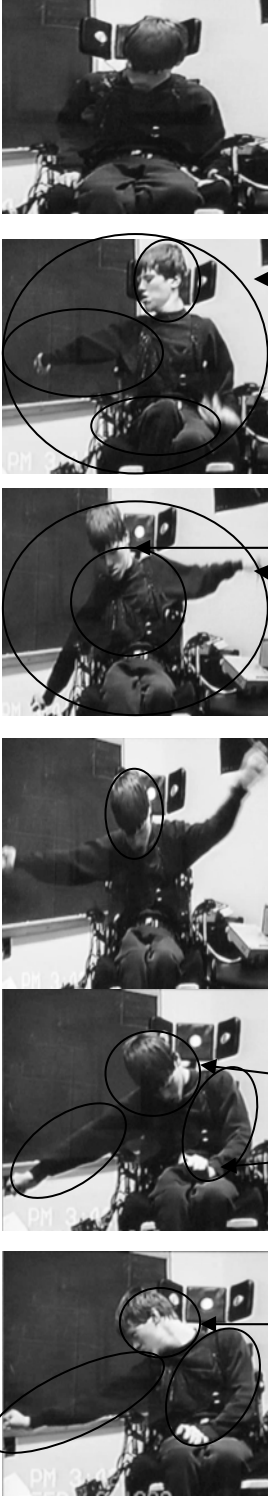
<p>Condition B Co-constructive Narrative 'Cowboy goes to town' Narrated Stream</p> <p><i>..Cowboy going into town on his horse</i></p>	<p>Segmented Gesture Stream</p> 	<p>(t) <i>Timeline</i> <i>Min, sec</i></p> <p>00, 09</p> <p>00, 14</p> <p>00, 16</p> <p>00, 19</p> <p>00, 21</p> <p>0.24</p>	<p>Phase One Corporeal Dynamic Annotation</p> <p>Starting posture At rest</p> <p>1st ENACTION BEGINS 0.14 Maximum volitional involvement, 6 on scale Corporeal body zone involvement Z1-4, indicated by circles and ellipses Clear intentional action holistic body gesture strategy unfolding. Reveals features of: Abstraction of Action; Use of both peripersonal and extra-personal gesture space, indicated by concentric circles Manipulation of Action; Upper body movement, with both arms rise upwards, head lowers</p> <p>Representation of Object & person Right arm lowered, left arm moves to lap, head lowers to chin</p> <p>Interaction Description for narrative interaction Head moves to right,</p>
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Figure 7.2 a)-c) Video Montage and G-ABAS Analysis Condition B Co-Constructed Narrative. Neuro-atypical Case Study 2 NAT-CP5, 1st exemplar enaction from a series of 41 gestures, see Table 7.1 b). Consecutive frames manually segmented for corporeal dynamic, narrative features and levels G-IPA analyses. See text for corporeal narrative explanations.

Condition B
Co-constructive Narrative
'Cowboy goes to town'
Narrated Stream

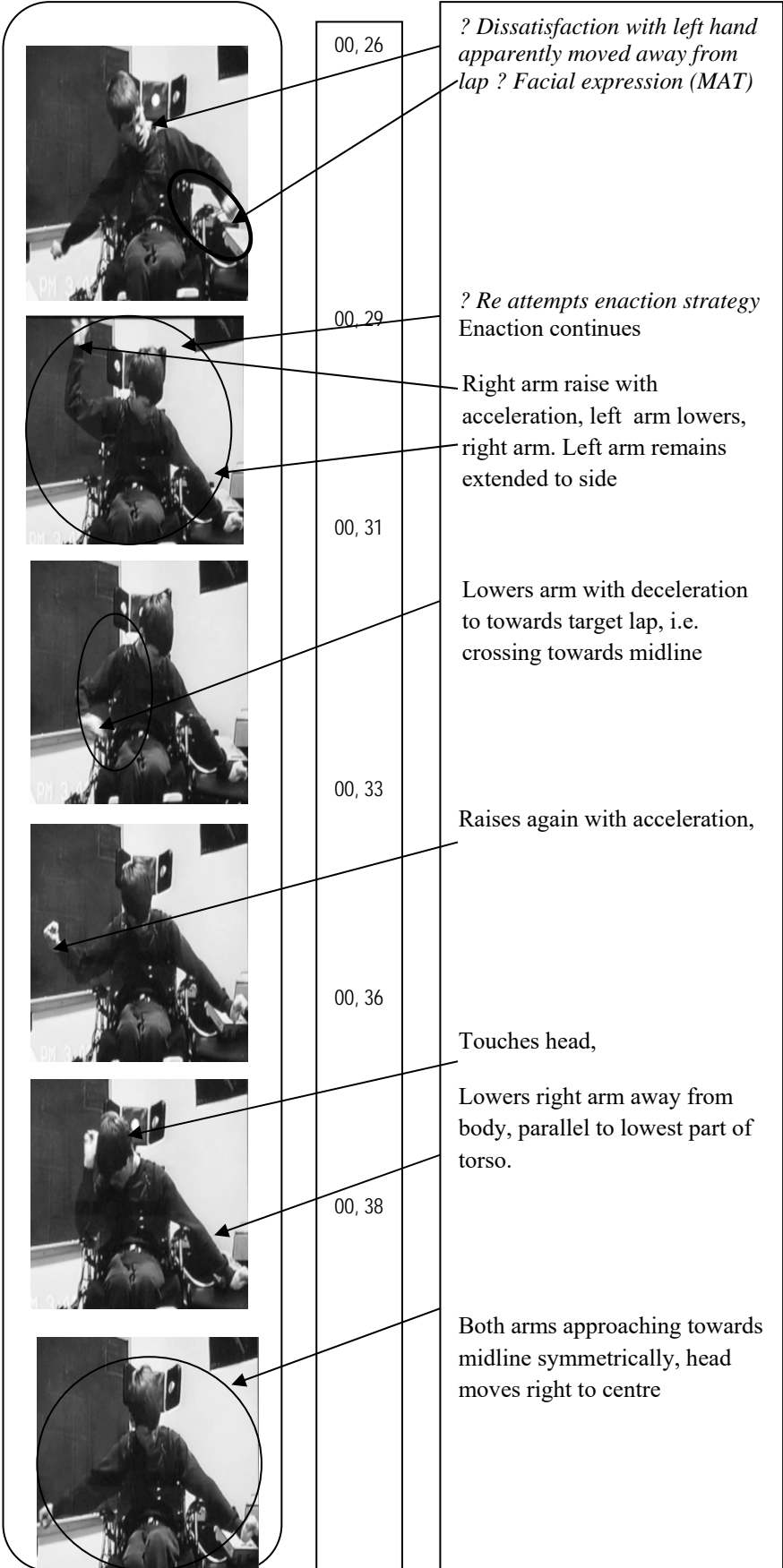


Figure 7.2 b

Condition B
Co-constructive Narrative
'Cowboy goes to town'
Narrated Stream

Good .when you're in position, you may want to do the up and dowe *motion on your horse....*
 And..... *Lasso*

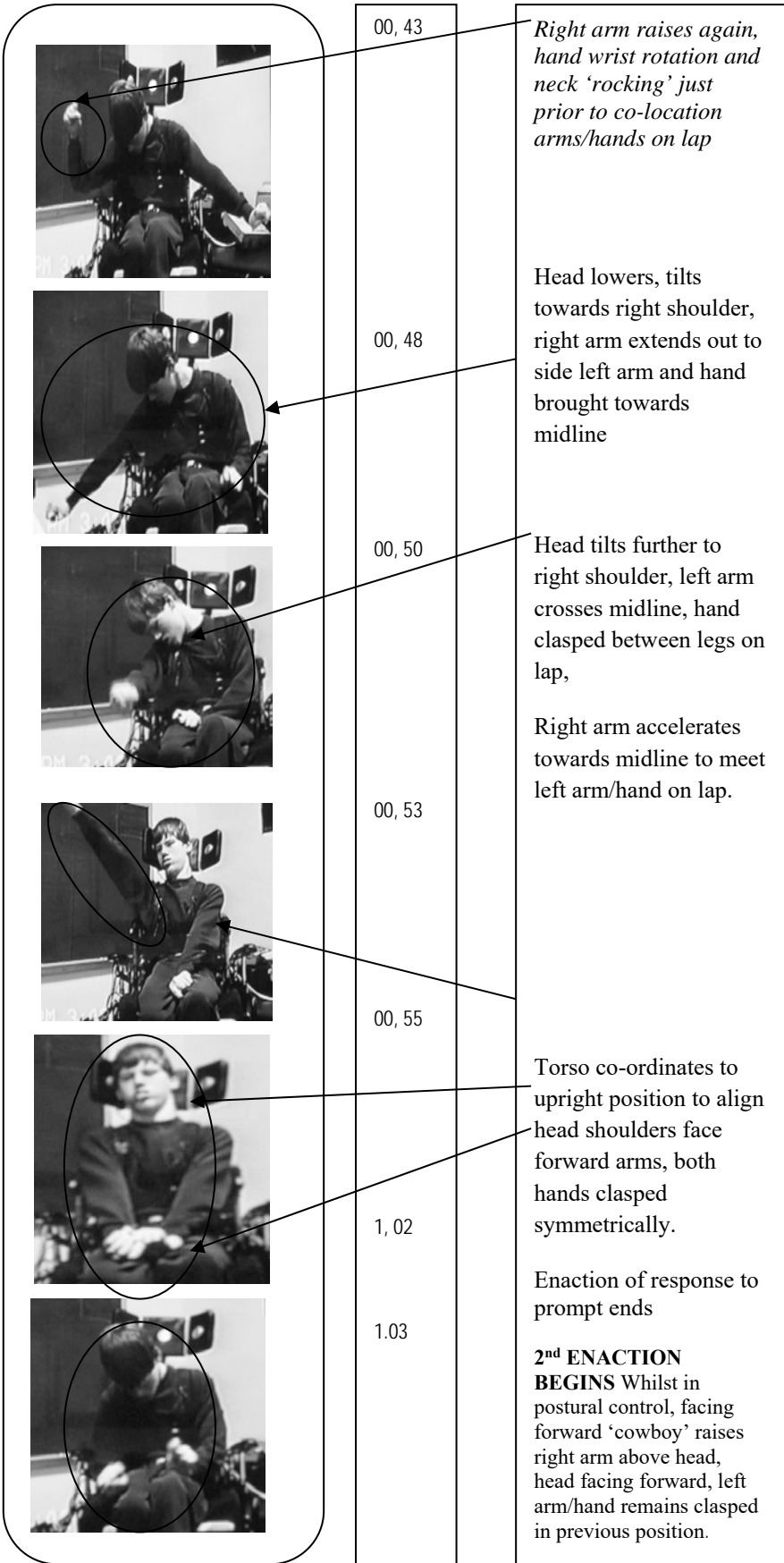


Figure 7.2 c

7.3.3 Interpretative Findings

In the sections that follow I illustrate how the adolescent's source of *narrative knowledge* is evident throughout his imaginative enactment. This fine grained narrative feature analysis provides evidence of the adolescent's capacity for both *creative interpretation* and *corporeal expression of narratives*. These are enacted appropriately in the narrative space and with emotional engagement. There is opportunity through improvisation for the *modulation of enactment* and manipulation of abstract thought. He does this interactively with social others who are co-present and others including artefacts that are imaginary. The nature of co-constructed narrative experiences is that it provides the space for expression of *novel* enactments to emerge. He is able to achieve a high score on the scale of narrative as he is able to reveal several characters and enact events. The session lasted for approximately 30 minutes.

The adolescent revealed his procedural, semantic and episodic knowledge through *Gesture-Action-Entities* expressed corporeally. These aspects of cognition show how he has the ability to synthesise and re-express perceptual and tacit knowledge across different modalities. This knowledge becomes embedded in the story structure and includes characters, events and the relations between these narrative features. Figures 7.2 a) - c) show how the enactment unfolds in narrative gesture space. The feature and analyses themes are presented in summary form in Table 7.2 for 41 discrete enactments performed during the session.

Condition B: Co-Constructed Narrative Gesture Stream exemplars													
Co-participant Code: NAT- CP5. Story Line: 'Cowboy rides into town'													
No. in seq.	Enaction descriptor /Fragment of narration	Corporeal Narrative Features	S K N	N G S	M A T	N E S	No. in seq.	Enaction descriptor /Fragment of narration	S K N	N G S	M A T	N E S	Corporeal Narrative Features
1	<i>Cowboy on horse rides into town</i>	Self as protagonist, Horse 1 st [IO] and reins 2 nd [IO]	+	+	+	+	22	<i>So-long</i>	+	+	+	+	IMP with [SO] and [ISO's]
2	<i>Lasso</i>	3 rd [IO]	+	+	+	+	24	<i>Push out of saloon doors</i>	+	+	+	+	Scene Change IMP with [IO]
3	<i>Push open saloon doors</i>	Scene change 4 rd [IO]	+	+	+	+	25	<i>It's raining</i>	+	+	+	+	Scene Change IMP with 12 th [IO]
4	<i>Do you want a beer stranger?</i>	IMP	+	+	+	+	26	<i>It's bright</i>	+	+	+	+	Scene Change IMP 13 th [IO]
5	<i>Response</i>	IMP	+	+	+	+	27	<i>There's a rainbow</i>	+	+	+	+	Scene Change IMP with 14 th [IO]
6	<i>A dollar</i>	5 th [IO]	+	+	+	+	28	<i>Listen</i>	+	+	+	+	IMP with self
7	<i>Put money on bar</i>	IMP with 6 th IO	+	+	+	+	29	<i>Dust down clothes</i>	+	+	+	+	IMP with self And 15 th [IO]
8	<i>Catch beer glass</i>	IMP with 7 th [IO]	+	+	+	+	30	<i>Pat horse haunches</i>	+	+	+	+	IMP with [IO]
9	<i>Smoke cigar</i>	IMP with 8 th [IO]	+	+	+	+	31	<i>Lead horse by reins</i>	+	+	+	+	IMP with 16 th [IO]
10	<i>Stranger 1 'tall'</i>	IMP with 1 st [ISO]	+	+	+	+	32	<i>Shake hands 'howdy stranger'</i>	+	+	+	+	IMP with [ISO]
11	<i>Large/fat</i>	IMP	+	+	+	+	33	<i>Hammer/request horse to be shod</i>	+	+	+	+	IMP with 17 th [IO] and 3 rd [ISO]
12	<i>Knock on door</i>	IMP with 9 th [IO]	+	+	+	+	34	<i>Beckon daughter</i>	+	+	+	+	IMP with 4 th [ISO]
13	<i>Open door</i>	IMP	+	+	+	+	35	<i>Violin</i>	+	+	+	+	IMP with 18 th [IO]
15	<i>Money on table</i>	IMP with 10 th [IO]	+	+	+	+	36	<i>Look at hills (distance)</i>	+	+	+	+	IMP with 19 th [IO]
16	<i>Deal cards</i>	IMP with 11 th [IO] and 2 nd [ISO's]	+	+	+	+	37	<i>Point to hills</i>	+	+	+	+	IMP
17	<i>Look at others</i>	IMP with [ISO's]	+	+	+	+	38	<i>Stare</i>	+	+	+	+	IMP
18	<i>Check cards</i>	IMP [IO]	+	+	+	+	39	<i>Pay money to blacksmith</i>	+	+	+	+	IMP with [IO] and [ISO]
19	<i>Play cards</i>	IMP	+	+	+	+	40	<i>Shoot</i>	+	+	+	+	IMP with 20 th [IO]
20	<i>Gather money</i>	IMP	+	+	+	+	41	<i>Wave goodbye</i>	+	+	+	+	IMP with [SO] and [ISO's]
21	<i>Push money away</i>	IMP	+	+	+	+		<i>End of CCN</i>					

Table 7.2 Case Study 2 Corporeal Narrative Feature Analyses 'Cowboy comes to town' exemplar. Illustration of 41 isolated Co-Constructed Narrative gestures enacted during approx 30 minute interaction. **Key:** Source of Narrative Knowledge [SNK], Narrative Gesture Space [NGS], Manipulation of Abstract Thoughts [MAT], Narrative Emotional Space [NES], [IO] Imaginary Objects, [IMP] Improvisation, [SO] social other, [ISO] imaginary social other. Scale of Narrative [SN] is 6

Participatory Sense-Making and Improvisation

Both the young person with severe speech and motor impairment and co-participating researcher co-construct a narrative. No time constraint is given, although the interactive pace is maintained collaboratively. The young person performs the gestural stream based on the script delivered orally by the co-participating researcher/narrator/co-actor. This narrative script was built by the researcher using prior knowledge of the gestural ability of the adolescent. This was informed by the initial observations of their interaction in their school setting and their gestural performance whilst they contributed gesture to Condition A, the adapted charade game.

The nature of co-constructed interaction offers the opportunity for improvisation in response to other socially present partners, i.e. the researcher (co-actor) and the familiar communicator (speech therapist, not shown). The narrator responds to the young person's corporeal expressivity. Either may improvise to assist the pace of the co-constructed story. The adolescent is free to select what is salient for the re-telling of the story from the narration. The adolescent enacts the story using his *imagination* freely.

Narrative Gesture Space

In his enaction the young person takes the point of view (POV) of the main protagonist revealed through his gestures, i.e. he becomes the cowboy. His *point of view* illustrates how his personal narrative is grounded in the story word context, i.e. the *cowboy coming to town*. To my knowledge the adolescent has never, e.g. ridden a horse, drunk or smoked in a saloon bar, although he may well have seen movie/film/static images and be familiar with the genre of such story narratives.

The synchronization of complex action with overall body posture makes the character and associated objects in the scene *visible*. In the narrative scene he extends his gesture space from *peripersonal* through *extra-personal* (reaching) to *far space* (i.e. with distance gaze). The young person shows how he can maintain the integrity of the narrative gesture and emotional space. This continues when the complexity of the interaction increases, e.g. when interacting with the co-participating researcher as they become a co-actor, i.e. the bartender in the scene. This is illustrative of the nature of complex improvised interaction.

Manipulation of Abstract Thought: Self, Social others and Artefacts

Imaginary notions are creatively performed revealing various manipulations of abstract thought, e.g. search for a stranger, conveying emotions. In the region of 20 imaginary objects are created; they are listed in Table 7.2. Four examples are described here. The first,

second and third are the horse (1st) with reins (2nd) and a rope lasso (3rd) respectively. These objects are inferred by location and interaction as the enactions unfold, e.g. the horse is inferred from the seated and riding posture; the reins by the precision grip and/or grasp posture of the hands; the lasso, by the lasso gesture (Gesture sequence numbers: 1 and 2). Later in the story the horse is patted on its haunches and led by its reins (Gesture sequence numbers: 30 and 31). The 7th is the imaginary *beer glass* that the young person attempts to catch as it slides along the saloon bar. In this instance *the bar* is physically improvised by the researcher/co-actor using their arms crossed over momentarily; they then slide the imaginary glass with one hand towards the *cowboy*. The adolescent's enactions can also reveal descriptions of *four imaginary social others*, i.e. non-present characters such as *a stranger, card playing companions, the blacksmith and the daughter*.

Interaction description Performance Strategies and Their Implications

The adolescent is considered to have successfully achieved a *Performance Strategy* with a distinct spatial '*kinematic and narrative profile*'. This was annotated together with agreed interpretations. From a clinical perspective, it should be noted that these particular enaction exemplars involved the persistent crossing of midline of the torso, an action not normally considered to be performed with ease. In addition, the young person was able to control his movements in close proximity to the co-participating researcher in the role of the bartender. Such a level of controlled intentional action in relation to a social other is atypical for young people with this level of motor compromised movement due to cerebral palsy, i.e. level V. Such movements had not previously been documented in the case of this adolescent. His repertoire of holistic gestures is performed with co-ordination of the upper body, arms bi-manually and head and torso used for stabilisation. These movements occurred throughout the enacted story. The enactions involve complex and often *composite* dynamic kinematic profiles involving e.g. *synchrony of acceleration, deceleration and rhythm of an explicit action*, for example when enacting riding an imaginary horse. Furthermore, these body performance strategies are modified when the head, torso, arms and hand embody and take up position and execute dynamic action in relation to imaginary objects and parts of objects. For this individual, the level of corporeal co-ordination included significant postural changes. These repertoires of intentionality are not typically found in clinical, educational or home settings. The integrity of the scene in terms of maintaining features such as '*boundary and surfaces*' is described. These include, e.g. an adapted *precision grasp* for imaginary objects such as beer, money and a violin. In addition, although not the focus of the G-ABAS or G-

IPA, vocalizations were attempted. The presence of this feature suggests the potential use of more than one modality, i.e. corporeal gesture with vocalization. This has further implications for the development of therapeutic interventions.

Integration

Finally, even in this apparently simple enacted story, sophisticated strategies for knowledge transfer and conceptual integration across modalities begin to be revealed. A visualization of how conceptual integration is inferred is summarised in Figure 7.3. In Fauconnier and Turner's (2002) generic space they model inputs; in C-I-A these are considered influences which may involve prior knowledge or projections, as previously discussed. These types of spatial and kinaesthetic cognitive attributes both support both enaction decisions and guide prospective performance strategies. The resulting interactions and gestural performance can reveal prospective action and adaptation capacities, e.g. ability to improvise.

In summary, their *Gestural Performance Strategies* reveal their intentional actions expressed through their intra and intersubjective embodied, extended and exbodied interactions. Their *Enaction Decision* can involve *anticipation* supported by prior knowledge or *projection*.

These observations, taken together with the adolescent's latent ability to control intentional action at this level, are significant. These features collectively belong to the source of narrative knowledge, scale of narrative, narrative gesture space, manipulation of abstract thought and narrative emotional space themes.

These analyses are illustrative of *structure and resource configurations* that relate to participatory-sense-making which are embodied in the C-i-A framework and are discussed again in Chapter 8.

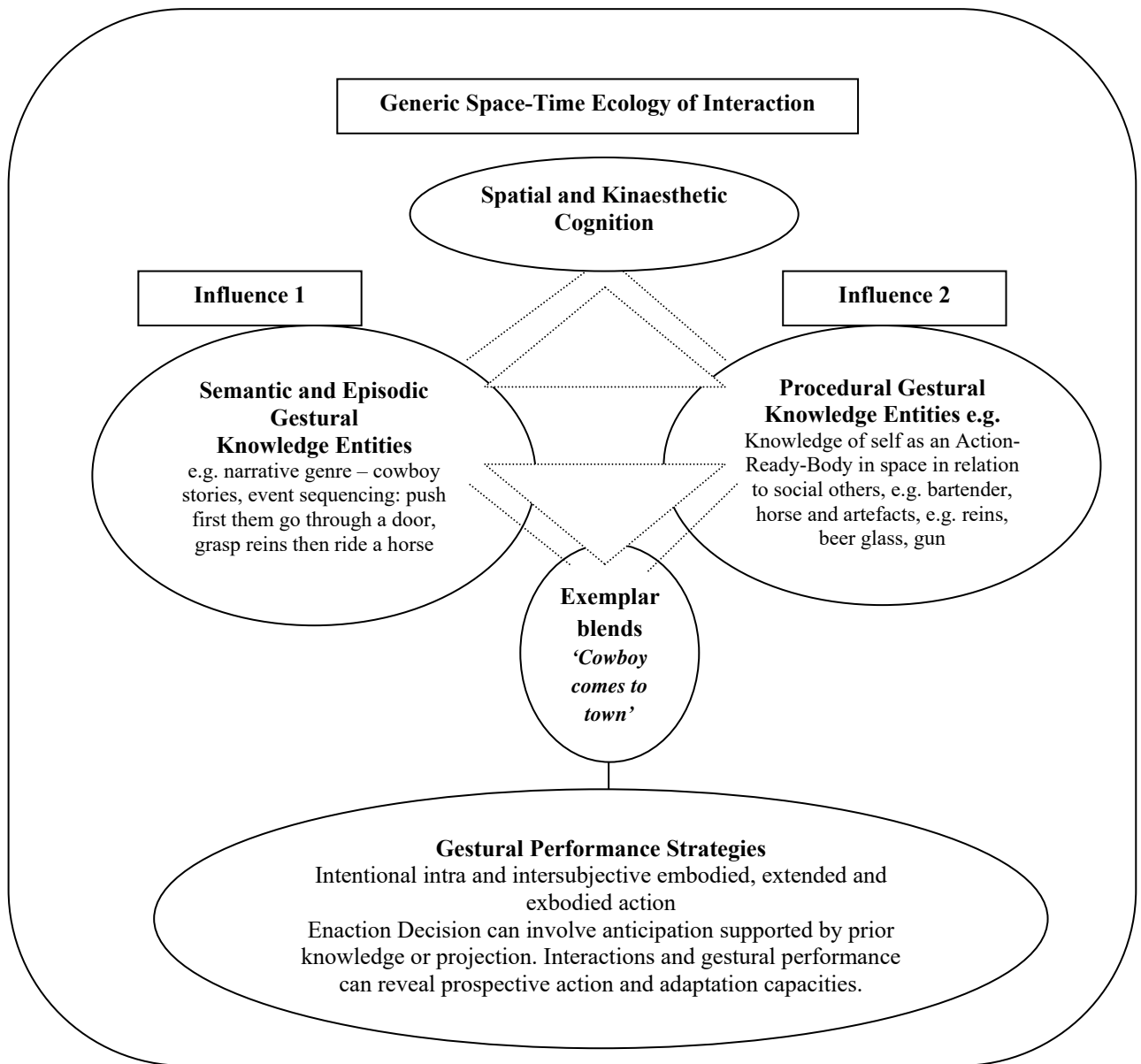


Fig.7.3 Shows a Generic space blending diagram extended and developed after Fauconnier and Turner (2002). It illustrates the notion of conceptual integration within the C-i-A framework. Features of performance capacity and decision pathway for a given co-constructed narrative enaction exemplar are visualized; see also Panayi (2011; 2012 and Panayi, 2014).

7.4 Phase Two Analyses: Condition C Manipulation of Artefacts

7.4.1 Case Study 3 Artefact No. 3 Chocolate Doughnut (play food)

In *Case Study 3*, gestures are enacted by a neuro-atypical female child with severe speech and motor impairment due to cerebral palsy. She was aged 10.7 years at the time she contributed to the Child Gesture Corpus. She attended a special school in the USA. Her co-participant identifier code is denoted by NAT-CP7.

Condition C describes the manipulation of artefacts condition during a co-design session. The focus of the session is for the child to explore and play with objects to inform the design of future technology interfaces. The child is given an initial prompt for the exploration and supportive suggestions, after which she are free to initiate intentional movements. Acknowledgement is given when a gestural interaction/enaction is achieved. Her enactions may involve significant cognitive and physical effort, as is the case in the exemplar depicted. Details of the methodology and protocol for Condition C have been presented in Chapter 4. Exemplar artefacts have been given in Chapter 6. The design interaction lasted approximately 30 minutes.

The exemplar that follows shows the interaction sequence for Artefact No.3. The artefact is placed flat on the child's communication tray and initially held still by the co-participating researcher. A second co-designer/researcher and therapist are also present. These features reveal the young person's participatory-sense-making abilities in relation to the self (protagonist), social other and the other as artefact. These *others* may be present in the real world, the imaginary or hybrid scenarios.

7.4.2 Application of Phase Two G-ABAS Annotation, Level II G-IPA and Findings

In this section I illustrate a simplified analysis for corporeal narrative features described as relational narrative events, based on Phase Two of the G-ABAS ontology. This analysis is guided by level II G-IPA interpretative questions. Details of the annotation system are provided in Chapter 5. Codes are provided in the appendices. Corporeal Dynamic feature analyses were also presented in Chapter 6.

Figure 7.4 a)-d) shows the interaction for one exemplar, Artefact 3, a Chocolate doughnut (play food). It is presented through video montage. The *narrative stream* in this case is an extract from the design session. It is provided by the researcher, see annotations right hand box. The *gesture stream* is made up of selected segmented consecutive video frames, presented in the central panel. The timeline for interaction with the artefact is shown in the panel to the right of the gesture stream video frames. The last panel on the right

contains the corporeal narrative annotation (without codes) for the sequence of video frames. Regions of corporeal narrative interest (ROI) are highlighted by arrows linked to the comments.

This extract of the performance is particularly significant as it illustrates the young person's *perseverance*, level of *manipulation* and the apparent attempts to improvise play, i.e. *take control and modify their intentional actions on the fly*. The young person's manipulation and interaction with the artefact lasted for about 5.5 minutes. Table 7.4 summarizes 14 points of interest related to the ROIs during this artefact interaction.

7. 4. 3 Interpretative Findings

In the sections that follow I illustrate how this child's source of *narrative knowledge* is evident throughout her imaginative enaction. This fine grained narrative feature analysis provides evidence of the child's capacity for *creative corporeal interaction with real artefacts*. These are enacted appropriately in the narrative space and with emotional engagement. There is opportunity through improvisation for the *modulation* of her enactions and manipulation of abstract thought. She does this interactively with social others and others as imaginary social others and artefacts.

The nature of design session experiences is that it provides the space for expression of *novel* enactions to emerge. She is able to achieve a fair score on the scale of narrative. However her score is limited due to the nature of the design interaction. Through *Gesture-Action-Entities* expressed corporeally the child reveals her procedural, semantic and episodic knowledge. These aspects of her cognition show how she has the ability to synthesise and re-express perceptual and tacit knowledge across different modalities. This knowledge becomes embedded in Figures 7.4 a) - d) which shows how the enaction unfolds in narrative gesture space. The feature and analyses themes are presented in summary form in Table 7.3 for 14 discrete enactions performed during the session.




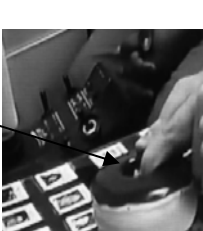



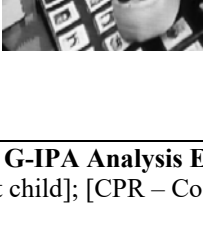
Condition C Manipulation Artefact No: 2 Play food Chocolate doughnut	<i>(t)</i> Timeline Seconds		<i>(t)</i> Timeline Seconds	Phase One Corporeal Dynamic to Two Corporeal Narrative Annotation
[CPT] Are you going to get it Sarah?	03,24		03,20	Next artefact introduced....not real, must not eat it!...too tempting, good enough to eat...
	03,30		03,25 - 03,29	First point of contact with artefact (toy food – chocolate doughnut), in response to touch pressure moves away from finger, initial contact lost
	03,34			
[CPR] ...Ok... what I have in mind is this is a plastic doughnut..	03, 57			
Artefact brought into reach by [CPR] and held	04,04			
see if you can touch it in the middle.. how you can touch it..	04,07			
, whether you can stroke it...	04,16			
whether you can push it just explore...see what you can do... just to give me ideas				

Figure 7.4 a) - d) Video montage G-ABAS and G-IPA Analysis Exemplar Chocolate Doughnut, extract from video transcript Key: [CPC – Co-participant child]; [CPR – Co-participant Researcher] and [CPT – Co-participant Therapist]


<p>Condition C Manipulation Artefact No: 2 Play food Chocolate doughnut</p>	<p><i>(t)</i> <i>Timeline</i> <i>Seconds</i></p>		<p><i>(t)</i> <i>Timeline</i> <i>Seconds</i></p> <p>04,25</p> <p>04,26</p> <p>04,27</p> <p>04,28</p> <p>04,30</p> <p>04,33- 04,36</p>	<p>hand in clenched fist posture, rotate to contact artefact with back of the hand slides over surface away from the body.</p> <p>Rotation of wrist inwards with thumb upwards, hand pushing downwards on surface of doughnut</p> <p>Further rotation of hand on surface and opening of clenched fist, fingers</p> <p>Closing of fingers to clasp edge of doughnut</p> <p>Pull back of finger? stroke micro-gesture, return to clenched fist posture</p> <p>Fingers (second, third, fourth) extended, stroking micro-gestures seen, i.e. repeated contact with edge of doughnut, with pushing down on chocolate surface with wrist.</p>
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Figure 7.4 b)






<p>Condition C Manipulation Artefact No: 3 Play food Chocolate doughnut</p>	<p>(t) <i>Timeline</i> <i>Seconds</i></p>		<p>(t) <i>Timeline</i> <i>Seconds</i></p>	
<p>[CPR]...Oh nice, Oh can see that chocolate on your hands S, [CPR] just as well it's not real</p>	<p>04,37-04,43</p>		<p>04,44</p>	<p>Rotation of wrist to make underside visible? Checking for chocolate?</p>
<p>[CPR]..would be covered by now..... 04,47 [CPR]... sticky</p>	<p>04,45</p>		<p>04,48 - 04</p>	<p>Returns to stroking micro-gesture posture</p>
<p>[CPR].... Best place to be artefact placed closer to child and on left side</p>	<p>05,25</p>		<p>05,27</p>	<p><i>Modulation on the fly</i> put finger in middle...</p> <p>Head moved closer to artefact, left hand clenched fist loosened, opens to extend forefinger into doughnut hole (1)</p>
			<p>05,36-05,37</p>	<p>Micro-gesture repeated (2), left hand posture fist more open, all fingers open and forefinger curved to follow contour of doughnut into hole.</p>

Figure 7.4 c)

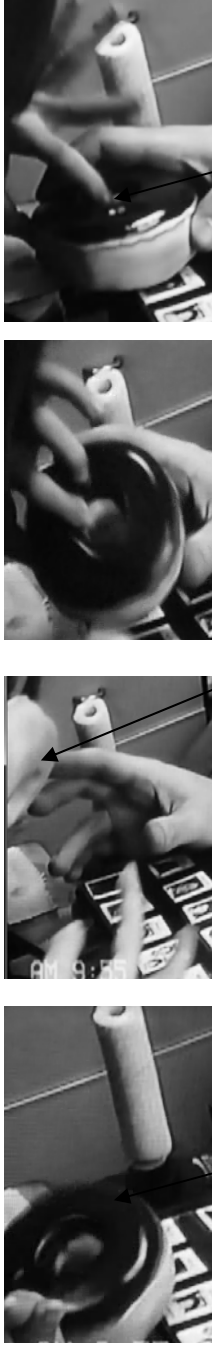
<p>Condition C Manipulation Artefact No: 3 Play food Chocolate doughnut</p> <p>Laughter [CPRs] and [CPT]...you going to taste it right...whip the chocolate off?</p> <p>....unfortunately they do not taste as good as they look [CPR]</p>	<p>(t) Timeline Seconds</p>		<p>(t) Timeline Seconds</p> <p>05,41- 05,44</p> <p>05,45</p> <p>05,50</p> <p>05,56</p>	<p>Micro-gesture repeated (3), left hand posture fist more open, all fingers open and forefinger curved to follow contour of doughnut into hole, attempt at precision grasp, i.e. picking up</p> <p>Successfully raised away from [CPR] hold</p> <p>Taken towards mouth for improvised eating!</p> <p>Artefact dropped by [CPC].</p> <p>End of Play/Exploration for Artefact 3</p>
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Figure 7.4 d)

Condition C Manipulation Artefact No: 3 Play food Chocolate doughnut Co-participant Code: NAT- CP7 Design Session: 'Future Computer interfaces'													
No. in seq.	Enaction descriptor /Fragment of narration	Corporeal Narrative Features	S K N	N G S	M A T	N E S	No in seq.	Enaction descriptor /Fragment of narration	S K N	N G S	M A T	N E S	Corporeal Narrative Features
1	[CPT] Are you going to get it Sarah? Next artefact introduced....not real must not eat it!...too tempting good enough to eat...	Self as co-designer (POV)	+	+			8		+	+	+	+	Pull back of finger? stroke micro-gesture, return to clenched fist posture
2	[CPR] ...Ok... what I have in mind is this is a plastic doughnut.. Artefact brought into reach by [CPR] and held	First point of contact with artefact (toy food –chocolate doughnut) IMP [SO]	+	+	+	+	9		+	+	+	+	Fingers (second, third, fourth) extended stroking micro-gestures seen, i.e. repeated contact with edge of doughnut, with pushing down on chocolate surface with wrist.
3	see if you can touch it in the middle.. how you can touch it.. , whether you can stroke it.... whether you can push it just explore...see what you can do... just to give me ideas	in response to touch pressure moves away from finger, initial contact lost IMP	+	+	+	+	10		+	+	+	+	Rotation of wrist to make underside visible? Checking for chocolate?
4		hand in clenched fist posture, rotate to contact artefact with back of the hand, slides over surface away from the body. IMP	+	+	+	+	11		+	+	+	+	Returns to stroking micro-gesture posture
5		Rotation of wrist inwards with thumb upwards, hand pushing downwards on surface of doughnut. IMP	+	+	+	+	12		+	+	+	+	Modulation on the fly put finger in middle...
6		Further rotation of hand on surface and opening of clenched fist, fingers. IMP	+	+	+	+	13		+	+	+	+	Head moved closer to artefact, left hand clenched fist loosened, opens to extend fore-finger into doughnut hole (1)
7		Closing of fingers to clasp edge of doughnut. IMP	+	+	+	+	14		+	+	+	+	Micro-gesture repeated (2), left hand posture fist more open, all fingers open and fore finger curved to follow contour of doughnut into hole

Table 7.3 Case Study 3 Illustration of Condition C Manipulation of Artefact enacted with Chocolate doughnut during approx 30 minute interaction. **Key:** Source of Narrative Knowledge [SNK], Narrative Gesture Space [NGS], Manipulation of Abstract Thoughts [MAT], Narrative Emotional Space [NES], [RO] Real Objects, [IMP] Improvisation, [SO] social other, Scale of Narrative [SN] is 4

Condition C Manipulation Artefact No: 3 Play food Chocolate doughnut Co-participant Code: NAT- CP7 Design Session: 'Future Computer interfaces' Table 7.4 contd.						
<i>No. in seq.</i>	<i>Enaction descriptor /Fragment of narration</i>	<i>Corporeal Narrative Features</i>	S K N	N G S	M A T	N E S
11		Micro-gesture repeated (3), left hand posture fist more open, all fingers open and forefinger curved to follow contour of doughnut into hole, attempt at precision grasp, i.e. picking up IMP	+	+	+	+
12		Successfully raised away from [CPR] hold IMP [SO]	+	+	+	+
13		Taken towards mouth for improvised eating! IMP [RO] [SO]	+	+	+	+
14		Artefact dropped by [CPC].				
15		<i>End of MOA session</i>				

Table 7.3 contd. **Case Study 3** Illustration of Condition C Manipulation of Artefact enacted during approx 30 minute interaction. **Key:** Source of Narrative Knowledge [SNK], Narrative Gesture Space [NGS], Manipulation of Abstract Thoughts [MAT], Narrative Emotional Space [NES], [RO] Real Objects, [IMP] Improvisation, [SO] social other, Scale of Narrative [SN] is 4

Participatory Sense-Making Improvisation

In this Case Study the young person with severe speech and motor impairment and the co-participating researcher participated collaboratively in a design session. Although no time constraint is given, the interactive pace is maintained. The narrative script is built by the researcher using prior knowledge of the gestural ability of the child. This knowledge is based on initial observations made in the child's school. It is also informed by the child's reduced gestural performance during their interactions whilst they played the adapted charade game in Condition A.

This type of ludic interaction session offers the child opportunities for improvisation with both artefacts and others who are socially present. These include the researchers (co-designers) and their familiar communicator, e.g. speech therapist (not shown). The co-designers respond to the young person's corporeal expressivity. Either co-participant is free to improvise to assist the pace or nature of the session. The child is initially prompted with

suggestions for interaction. The child performs her gestural enaction freely using her *perceptual experience, affordances* and *imagination*. The child is able to engage, actively participate and improvise during these interactions. Improvisations occur when physical artefacts take on a role in the enaction that can reflect real a world situation, e.g. eating doughnut (this child is normally tube fed).

Narrative Gesture and Emotional Space

The child (principal gesturer) takes the point of view/role (POV) of a co-designer. This illustrates how the narrative is grounded in the real world context, i.e. exploration and play. To my knowledge the child has never participated in an interface design session. In addition, opportunities for open-ended play may have been limited due to her level of physical compromise, cerebral palsy Level V. However, she will undoubtedly have observed, seen movie/film/static images or be familiar with the notion of general play.

The narrative scene of her gesture space is largely restricted to *peripersonal* space, although there are occasions when she extends her body through *extra-personal* (reaching) when improvising with the co-designer/researcher. At an emotional level she interacts appropriately, e.g. when the researcher/co-designers or therapist laugh in response to the child's explicit action or expressions. Thus, the young person shows how she can maintain the integrity of the narrative gesture and emotional space when interacting with the co-participating researcher/co-designer and/or therapist.

Manipulation of Abstract Thought: Self, Social others and Artefacts

The ability to engage with an imaginary object created through improvisation is also evident. Imaginary notions are creatively performed revealing various manipulations of abstract thought, e.g. the presence of *an imaginary substance* (chocolate) on the hand and attempts to *eat* the play food. This happened on several occasions with other artefacts. Extended play-eating incidents included attempts at pretend chewing and biting, e.g. with pizza and chicken (not shown). Other manipulations included for example 'strumming' beads and textural string and moving over the surface of balls of different textural surfaces.

One example of particular interest occurred when difficulty was experienced by the co-participant in traversing a chocolate mould. It was suggested that her hand may be a *spider*. The child was motivated by being told that her co-participant was scared of spiders. What was observed was that in an instant the child's hand movement transformed into a spider. In such instances, the imaginary object is inferred by the context combined with both explicit action and interaction with others. In the case of the '*spider*' this imaginary object is

inferred through the posture of the hand and the finger micro-gesture movement as they travel across a surface. As the enaction unfolds, the evoked 'spider' leaves the surface of the physical artefact and travels on to the arm of co-designer/researcher; he improvises a fear response.

Interaction Description Performance Strategies and Their Implications

On several occasions the child persistently endeavours to synchronize complex actions, including accurate targeting with her left hand using her right for stabilization. This necessitated a range of strategies including adjustments in overall body posture.

From a clinical perspective, these analyses reveal that the child can persistently cross the midline of her torso. Such movements are not typically performed with ease by children with this level of compromised movement (level V). Importantly, the young person was able to control her movements in close proximity to the co-participating researcher in the role of the co-designer. This level of controlled intentional action in relation to a social other is atypical for severely motor compromised young people with cerebral palsy; see also Chapter 6. Such movements had not previously been documented in the case of this child.

This child successfully achieved a *Performance Strategy* with a distinct spatial '*kinematic and narrative profile*'. This was annotated together with agreed interpretations. Her repertoire of holistic micro-gestures is performed with co-ordination of the upper body, arms bi-manually where she uses her head and torso for stabilisation. These occurred throughout the design session. Cerebral palsy children with this level of physical compromise rarely produce such repertoires of controlled corporeal co-ordination. These movements have not previously been reported for this child in either school, home or clinical settings.

These enactions couple a complex and often *composite* dynamic kinematic profile involving e.g. *synchrony of acceleration (e.g. target action initiation) deceleration (point of contact with the object) and rhythm of an explicit action (e.g. stroking edge/grasping edge of doughnut)*. The integrity of the scene is described in terms of the child being able to maintain artefact features such as '*boundary and surfaces*', e.g. an adapted *precision grasp* for picking up play food, traversing surfaces of pieces of materials such a jelly mould surfaces or bubble pack (see gesture exemplar analyses, Chapter 6.)

It should be noted that despite severely compromised speech, i.e. dysarthria, the child attempts to make vocalizations. This illustrates the potential for the use of more than one modality to explore a child's expressive gestural capacity, i.e. corporeal gesture with vocalization.

The features revealed in these analyses collectively belong to the source of narrative knowledge, scale of narrative, narrative gesture and emotional space and manipulation of abstract thought themes. The analysis themes are summarised in Table 7.3 and shown in relation to narrative gesture space in Figures 7.4 a) - d). Through fine grained narrative feature analyses I have shown how the child's source of *narrative knowledge* is evident throughout her real world explicit action with physically present objects. I have provided evidence of the child's capacity for both *creative interpretation* and *corporeal expression of design narratives*. The interaction provides opportunity through improvisation for the *modulation of enaction* interactively with social others and others as real and imaginary artefacts.

Aspects of the enaction are described within the C-i-A framework as Gestural-Action-Entities, i.e. procedural, semantic and episodic knowledge revealed through their corporeal interaction with objects. This type of knowledge becomes embedded in the design session structure and includes exploration of the texture, shape and size.

Even in these apparently simple corporeal enactions, sophisticated perceptual-motor and cognitive strategies begin to be revealed. This child has definitive capacities for interaction with artefacts. They are expressed physically and cognitively through improvisation previously unseen by familiar therapists.

Integration

The child shows that she has the ability to synthesise and re-express perceptual and tacit knowledge in different modalities, i.e. verbal prompts and visual affordances to corporeal expressivity. This kind of knowledge transfer is supportive of theories that conceptual integration across modalities can be inferred. A visualization of how conceptual integration is inferred is summarised in Figure 7.5. It shows a Generic space blending diagram extended and developed after Fauconnier and Turner (2002). It illustrates the notion of conceptual integration within the C-i-A framework. Features of performance capacity and decision pathway for a given co-constructed narrative enaction exemplar are visualized see also Panayi (2011, 2012 and 2014). Influences are shown in terms of Semantic and Episodic Gestural Knowledge Entities in this exemplar, e.g. ludic kinetic play that unfolds during a design session. This involves the young person co-participating in interaction with veridical objects. They bring prior knowledge to, e.g. play food, action brought forth related to semantic and episodic structure affordances. Procedural Gestural Knowledge Entities are revealed through the young person expressing knowledge of self as an Action-Ready-Body in

space in relation to social others, e.g. co-designer/researcher and therapist. She interacts with material artefacts and her actions are related to concepts of, e.g. push, poke, pull and stroke. Thus, prospective action was brought forth and adapted in relation to her interaction with physical structure and affordance.

In summary these young people’s *Gestural Performance Strategies* reveal their intentional actions expressed through their intra and intersubjective embodied, extended and exbodied interactions. Their *Enaction Decision* can involve *anticipation* supported by prior knowledge or *projection*. Through these interactions and gestural performance the young person can reveal his/her capacities for prospective action and adaptation.

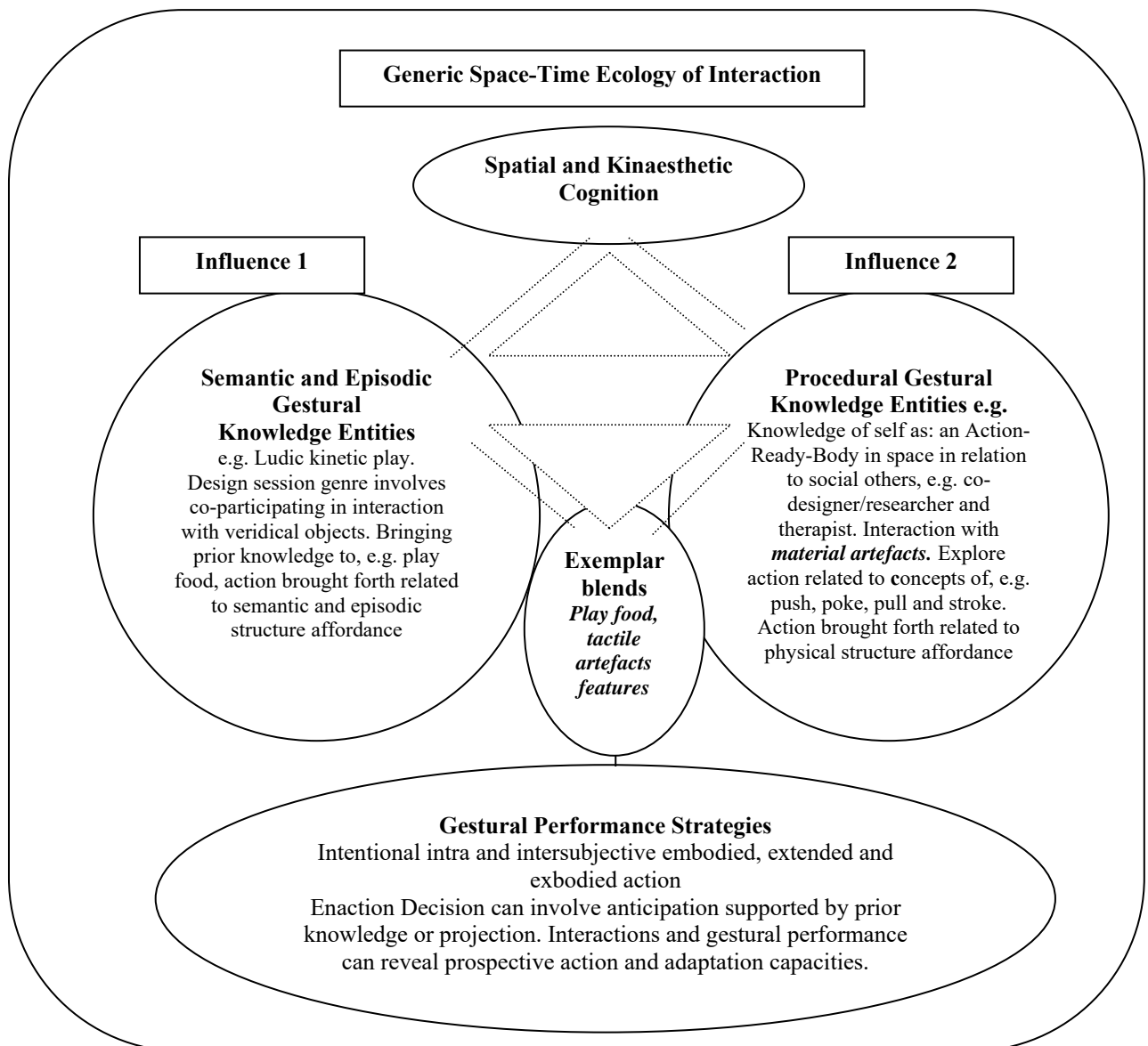


Fig.7.5 Integration corporeal space-time blending diagram Condition C. Shows a Generic space blending diagram extended and developed after Fauconnier and Turner (2002). It illustrates the notion of conceptual integration within the C-i-A framework. Features of performance capacity and decision pathway for a given manipulation of artefact exemplar are visualized see also Panayi (2011; 2012 and 2014).

These observations, taken together with the child's latent ability to control intentional action at this level, are significant. A major advantage of this type of design session narrative is that it provides the *experiential space* for expression of *novel* corporeal enactions to emerge. This repertoire of intentional movements, and micro-gestures in particular, could be developed interactively for use in future interface design. These findings support the second and third aims of my thesis.

Finally, these analyses are also illustrative of *structure and resource configurations* that relate to participatory-sense-making which are embodied in the C-i-A framework and are discussed again Chapter 8.

7.5 Corporeal Narrative Features Pattern Analyses for Case Study 2 and 3

In this section I summarise the findings for the Phase Two Corporeal Narrative Analyses for Case Studies 2 and 3. The Themes and features descriptors in relation to the G-IPA level II and III are presented in a matrix see Table 7.4. Micro examination and analysis of the exemplar gestures of children reveal their *Semantic and Episodic knowledge of action*, as explicitly expressed through what I have termed: Semantic and Episodic-Gesture Action Entities (S-GAE and E-GAE). These entities are expressed through a child's ability to co-ordinated enacted performances. Such enactions reveal a complex understanding of Cognition-in-Action that incorporates a detailed knowledge of embodied and exbodied human-artefact interaction and manipulation.

Although gesture is an ephemeral phenomenon these young people have the ability to reveal conceptual binding of both the material and abstract elements in moment-to-moment interactions. They can successfully express notions spatially using a range of enaction strategies that reveal several aspects of their corporeal cognition. These abilities unfold in the context of participatory-sense-making interactions.

However, the neuro-atypical profile means that as a biological system there may be initial constraints operating at both the physiological and cognitive level. An investigation of these constraints is beyond the scope of my thesis. The expression of these latent abilities does however have significant implications for the third aim of the thesis.

<i>Matrix of G-ABAS Corporeal Narrative Themes and features descriptor and G-IPA level II and III questions</i>	Source of Narrative Knowledge [SNK], e.g. imagination, ephemeral, binding		Narrative Gesture Space [NGS], e.g. point of view (POV), grounded, story world, enacted		Manipulation of Abstract Thoughts [MAT], e.g. mathematical, scientific and creative		Narrative Emotional Space [NES], e.g. contexts of 'stage space'; with corporeal dynamics Scale of Narrative [SN], e.g. 1-6	
Case Study	2	3	2	3	2	3	2	3
<i>What types of enaction strategies are expressed spatially?</i>	+ Imagination World knowledge	+ Imagination World knowledge	+ Holistic and object specific gesture	+ Holistic and object specific gesture	+ Creative pathway chosen imaginary object specific gesture	+ Creative pathway chosen to interact with specific veridical object features	+ Peri- personal/ allocentric and far space [SN]6	+ Largely peri- personal, some extension into allocentric 'spider improvisation' [SN] 4
<i>What does spatially expressed enaction reveal about corporeal cognition?</i>	+ Ability for conceptual integration Supra- modally	+ Ability for conceptual integration Supra- modally	+ Self as protagonist	+ Object and surface physical properties	+ Self/ other relations Covert/ Overt action	+ Self/ other relations Covert/ Overt action	+	+
<i>What evidence is there for participatory-sense-making?</i>	+ Ability to: -express discrete imaginary notions -understand and act in a co- constructive narrative	+ The role of play food both in imaginative play and the real world	+ Ability to improvise. Modulate on fly	+ Ability to improvise Modulate on fly	+ Ability to project thoughts in relation to non- present others/arte facts	+ Ability to project thoughts in relation to present others/ artefacts	+ Ability to improvise Modulate on fly	+ Ability to improvise Modulate on fly
<i>Can evidence from IPA I and IPA II be used to evaluate and validate theoretical models? Can evidence from IPA I and IPA II be used for comparative gesture studies?</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 7.4 Case Study 2 and 3 Phase Two Corporeal Narrative Themes and features descriptors in relation to the G-IPA level II and III questions matrix.

This young person uses Narrative Gesture Space [NGS] to express his point of view (POV) which is grounded in the story world, e.g. as the protagonist Cowboy. I have shown how they understand an object's physical properties, e.g. movement under pressure, surface, holes and spaces. He express his *source of narrative knowledge* [SNK] in terms of more concrete imaginary notion such as riding a horse, playing cards, playing a violin or shooting and pretending to eat play food.

Creative expression is seen in this young person's ability to improvise. In terms of the manipulation of abstract thoughts [MAT] this physical knowledge is expressed through enaction that is consistent with the narrative space. Example enactions include: 'catching *an imaginary beer*' from a co-participating actor who is physically present; '*playing cards*' with imaginary social others in an imaginary saloon bar. In Case Study 3 the child evokes an *imaginary spider* able to move across a surface previously found difficult to traverse. As a result they reveal more abstract knowledge in terms of notions of fear, e.g. frightening someone close by. Both these young people are able to successfully engage emotionally with the narrative space [NES]. This can be measured using a scale between: 1-6. An example of level 6 is achieved when the young person is totally engaged in the interaction, takes initiative and successfully extends the interaction.

I have shown how G-IPA can be used to evaluate and validate the C-i-A theoretical framework by instantiating these Gesture-Action-Entities. I would suggest that these data can be used as evidence for future comparative gesture studies which have a larger allocation of resources. The complexity and connectivity of such corporeal narrative ability are discussed further in Chapter 8. In the section that follows I illustrate potential application of these tools in pedagogic, clinical and design settings.

7.6 G-ABAS and G-IPA

Application in Pedagogic, Clinical and Design settings

7.6.1 Introducing the SKIP

In this section I apply the findings to illustrate the potential for applying the *G-ABAS* and *G-IPA* tools in pedagogic, clinical or design settings. They specifically address the third aim of my thesis and objective 6. The G-ABAS and the G-IPA tools have the capacity for scoring features, i.e. number present for each pattern cluster per gesture. However, scoring is not the focus of this thesis (see also Chapter 6). I combine the descriptions for annotation and questions for interpretative analyses to create a Spatial Kinaesthetic Interaction and Intelligence Profile (SKIP). This instrument is under development as part of the third aim of the thesis.

An illustrative series of simplified templates useful for initial documentation of Corporeal Dynamic and Narrative Feature Analyses are provided in Figures 7.6 a) and b). These would be useful to teachers, therapists and designers. They could be used with a minimal amount of training at low cost. I aim to develop these templates in the field as practitioner evaluation and validation tools. This work forms part of the future work for the C-in-A Framework.

7.6.2 SKIP Corporeal Gesture Sphere

Figure 7.6 a) provides a representational visual template for the 360° Corporeal Gesture Sphere. The concept of a gestural sphere takes inspiration from the art of oratory in antiquity and more contemporary notions of corporeal theatre and dance as previously discussed. Figure 7.6 b) is a matrix for recording simplified themes from the G-ABAS, i.e. Corporeal Dynamic and Narrative Features in relation to the G-IPA level I –III questions. This template can be used for recording the location of the performance, i.e. peripersonal egocentric, allocentric space and far space sectors in relation to the body zone and body part involvement. In Chapter 8 I discuss how I develop the Corporeal Gesture Sphere by extending Maturana and Varela's biological notation to visualize inclusive enacting unities.

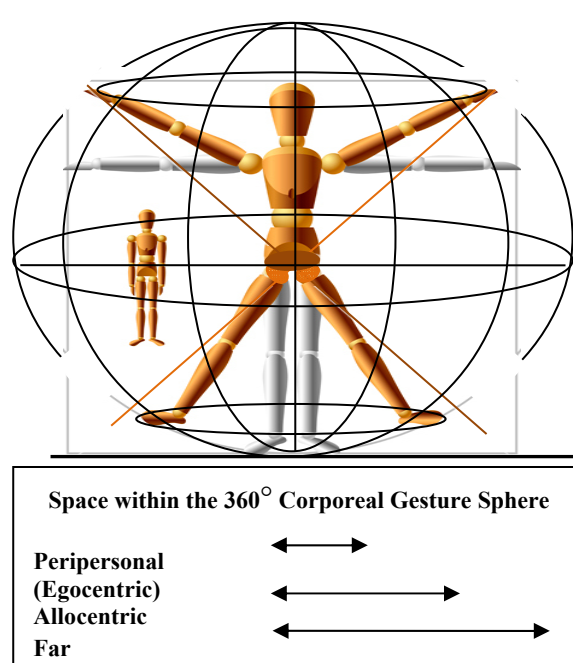


Figure 7.6 a) Summary SKIP Illustrative format for practitioner sessions for Corporeal Dynamic and Narrative Features G-ABAS and G-IPA level I -III observations and analyses.

Corporeal Dynamic and Narrative Features G-ABAS and G-IPA level I II and III				SKIP Session Comments and G-IPA Questions					
Co-participant Child Details				Practitioner Details				Location	
Session	1	2	3	G-IPA questions					
Procedural Gesture Action Entities				Semantic and Episodic-GAE's					
Abstraction of Action	+	+	+	Does the child perform an imaginary (en) action?	+	+	+	What types of enaction strategies are expressed spatially?	Source of narrative knowledge
Representation Schema		+	+		+	+	+	What does spatially expressed enaction reveal about corporeal cognition?	Narrative Gesture Space
Manipulation of Action			+			+	+		Manipulation of Abstracts Thought
Object Representation		+	N / A	Does the child perform an enaction with real object, social other?	+	+	+	What evidence is there for participatory-sense-making?	Narrative Emotional Space
Emotional Salience	+	+	+			+	+	4 6	Scale of Narrative 1-6
Interaction Description [ID]				Where does the child perform the (en) action?	Y	Y	Y	Can evidence from IPA I and IPA II be used to evaluate and validate theoretical models?	Summary of Corporeal Dynamic and Narrative Features
Level of Involvement Including novel gesture	3	5	6	Can you describe the child's level of involvement?	?	?	Y	Can evidence from IPA I and IPA II be used for comparative gesture studies?	
Modulation on the fly		+	+		+	+	+		

Figure 7.6 b) Illustrative Summary SKIP Corporeal Gesture Sphere with Corporeal Dynamic and Narrative Feature analyses using G-ABAS and G-IPA level I-III, a suggested format for practitioners. Key: Y-Yes; N-No;?- Possibly

7.6.3 SKIP Situated Practice Guides

Two evaluation and validation guides devised for use by a practitioners interested in *Situated Cultural Practice* are provided in Box 7.6 a) and b). This work forms part of a future publications see Chapter 9. The guidelines are directly informed by the empirical and theoretical works presented in my thesis. The ecological principles for these tools were introduced in chapter 2, see Arzubiaga et al. (2008), p 322. In Part I the left hand column provides comments on the context of use; in the right hand column the guidelines have specifically been adapted for child gesture studies.

Part I Context of Use	Situated Practice Guidelines adapted for Child Gesture Studies
Co- participants cultural practice Theoretical considerations	<p>Fieldwork Situating cultural practice is made visible in fieldwork events in which ecological validity is at stake Consideration could include: How does ecologically situated practice compare with theoretical models? See Cultural psychology (Cole, 1996), education, (Marshall & Rossman, 2006), enactivist paradigms (Panayi, forthc. 2012) If a cultural insider from the community is recruited, how is their 'ahistorical position in the community' evaluated? (Cole, 1998) What is the nature of the performance demand? (Lave, 1997)</p>
Design and participatory accessibility	<p>The design of research data collection procedures and task instructions for participants need to be aligned and culturally accessible Can they be applied inclusively?</p>
Co-participant roles	<p>Identifying roles Identify and document role (s) of the researcher (s). Take care to note of balance of 'power' (Cole, 1996)</p> <p>Participatory Design Is it appropriate for the co-participants to be involved in the design of research studies? How can this be structured? How can this be evaluated?</p>
Validity of observations I Theoretical & Empirical considerations	<p>Documenting the meaningfulness of the phenomenon Is the methodology ecologically and culturally valid? Consider structuring research to empower the collection of data by the community; this may provide more open-ended data. Such data may then be sampled from an 'ecologically valid' pool. Documenting the phenomenon Distinguish between embodied phenomena reflective of <i>effort</i> in relation to the situated activity or task, their role and the role of others and latent capacity Useful questions may include: What aspects of gesture phenomena are being investigated? What if the context was changed? How would the phenomena change over time? Is the methodology inclusive?</p>
Validity of observations II	<p>Are the analysis/interpretation tools suitable for the data? Ensure that the analysis tools have the power to interrogate the data Can the tools be applied to heterogeneous data at individual or group level?</p>

Box 7.6.1 a) Illustrative Situated Cultural Practice Guideline Part I Guideline context of use adapted for child gesture studies, proposed as an evaluation and validation tool. Developed after Arzubiaga et al. (2008), p 322, where references are included these are cited in the review.

Part II focuses on the *learning conditions* and Part III focuses on *interaction principles*. For my thesis the learning conditions in Part II focus on kinaesthetic learning where *doing- is-knowing* and cognition is reflected by the C-i-A construct. In Part III the interaction principles are informed from mime and physical theatre or hands-on re-patterning.

Once again both these guidelines place the focus on an Action-Ready-body. Importantly, they incorporate the concept of habits and skill that I have already discussed both from biological/neuroscience and philosophical perspectives. These guidelines form part of the outcomes that support the third aim of my thesis. I aim to trial these documents in the field as part of the future work of my thesis.

Part II Learning conditions	Relevance Check list & Notes and sources
Focus on the body both as an objective physical process and as a subjective process of lived consciousness	
Refine perceptual, kinaesthetic, proprioceptive, and interoceptive sensitivity that supports homeostasis and self-regulation	
Recognize habitual patterns of perceptual, postural and movement interaction with one's environment	
Improve movement co-ordination that supports structural, functional and expressive integration	
Experience an embodied sense of vitality and extended capacities for living.	
Part III Practice either by using interaction principles from mime and physical theatre or hands-on re-patterning	
Guides the student/client in initiating and practising improved movement coordination	
Activates and directs the attention of the student/client throughout the entire learning process	
Identify and define the student/client's habitual patterns of perceptual, postural and movement interaction	
Facilitates the refinement and focus of proprioceptive and kinaesthetic attention	
Recognize his/her habitual patterns of perceptual, postural and movement interaction with his/her environment	
Develop improved movement coordination and perceptual movement integration	

Box 7.6 b) Part II and Part II Situated Practice Guideline Adapted for child gesture studies and proposed as an evaluation and validation tool. Learning Conditions Key of Sources: developed after Arzubiaga et al. (2008), p 322, and ISMETA (2003), p5 Eddy (2009). Where references are included these are cited in the review. This work forms part of a future publication, Panayi (in prep).

In the next section I develop the SKIP tools to incorporate the analysis of experience in terms of the concept of Gestural Flow that was introduced in previous chapters.

7.6.4 Gestural Flow and Slow Processes

In this section I discuss two key aspects of the SKIP profile in terms of interactive sub-systems or processes as part of the analyses of experience. The first, *Gestural Flow*, has particular utility for practitioners. The second is Donald's theoretical notion of *slow process* which postulates a form of memory. He argues that this form of memory could support microgenetic, ontogenetic and phylogenetic notions of distributed cognitive networks. For my analysis I give an example of where neuro-atypical gestures could be placed within the spatio-temporal timeframe.

7.6.4.1 Gestural Flow

The notion of Gestural Flow was introduced in Chapter 3. Here I provide an illustration of how this activity could be documented. The analysis of experience is summarised in Table 7.5. *Gesture Flow I* provides descriptions of the channels in the model of the analysis of experience, after Csíkszentmihályi, (1988); Massimini & Carli (1988, p270). They describe states of arousal, flow, control, boredom, relaxation, apathy, worry and anxiety. I provide an illustration of how the experiential aspects of gestural flow could be described for three exemplar gestures from Condition A, the adapted charade games. They are namely: pretend to play the violin, lasso the steer and stroke the cat.

The lower part of the table provides a template *Gesture Flow II*. This shows how to evaluate the performance features of flow for gestural interaction. Seven flow performance features are illustrated for the 'pretend to play the violin' exemplar: *complete involvement in what you are doing*; *sense of ecstasy* (of being outside of everyday reality); *great inner clarity* (knowing that it needs to be done and you are doing it well); *knowing the activity is doable* (that your skills are adequate to the task); *sense of serenity* (no worries about oneself, and feeling of growing beyond the boundaries of ego); *timelessness* (thoroughly focused on the present, hours seem to pass by as minutes) and *intrinsic motivation* (whatever produces the flow becomes its own reward). These are ranked using a Likert Scale that I have devised where 5 is the highest level of involvement. Importantly, it should be mentioned that for performance item 4 (highlighted), this only becomes explicit once the young people have engaged in their initial session and experience success at expressing themselves corporeally. The concept of Gestural Flow can also be displayed graphically and discussed in relation to 1st and 2nd order dynamics; this forms part of my future work and form part of further publications.

Gesture Item Description	Channel 1-8 Descriptor	Channel 1-8 Descriptor Key	Description of channels in model of analysis of experience (after Csikszentmihalyi (1988); Massimini & Carli (1988), p270)	Comments Ideally to be carried out as reflective activity with young co-participant
<i>Pretend to play the violin</i>	1, 2,	1	AROUSAL High challenge, moderate skill	
<i>Lasso the Steer</i>	1,2	2	FLOW High challenge, high skill	
<i>Stroke the cat</i>	3,5	3	CONTROL Moderate challenge, high skill	
		4	BOREDOM Low challenge, high skill	
		5	RELAXATION Low challenge, moderate skill	
		6	APATHY Low challenge, low skill	
		7	WORRY Moderate challenge, low skill	
		8	ANXIETY High challenge, low skill	

C-in-A Being in Gesture Flow Template I

Gesture Item No: and Description	Flow Performance Feature	Evaluation of performance features of flow for gestural interaction	Likert Scale 1-5	Comments Ideally to be carried out as reflective activity with young co-participant
<i>Pretend to play the violin</i>	1	Completely involved in what you are doing – focused and concentrated	5	
	2	A sense of ecstasy – of being outside everyday reality	3	
	3	Great inner clarity- knowing that it needs to be done and you are doing it well	4-5	
	4	Knowing that activity is doable- that your skills are adequate to the task	3-5	
	5	Sense of serenity – no worries about oneself, and feeling of growing beyond the boundaries of ego	3-5	
	6	Timelessness- thoroughly focused on the present, hours seem to pass by minutes	3-5	
	7	Intrinsic motivation- whatever produces the flow becomes its own reward	4-5	

C-in-A Being in Gesture Flow Template II

Table 7.5 C-i-A Analysis of Experience Being in Gesture Flow I and II Template. This work forms part of a future publication, Panayi (in prep).

7.6.4.2 Slow Process

Importantly, the work of Donald (2007) provides a conceptualisation of evolutionary development that is theoretically consistent with the C-i-A framework. He postulates a model of memory with timescales that are sustained during the playing of games or the unfolding of a conversation. Such a subsystem could account for the type of perceptual binding that is experienced in the interactions presented in these case studies. Donald suggests approximate temporal ranges for what he terms ‘stable neural traces’ that support perceptual *binding* and *short term working memory* (ST-WM). He proposes a form of memory he terms

intermediate-term governance (ITG). Although the neural mechanism that underlies these temporal ranges may differ, the ITG is highly developed in humans.

Donald argues that intermediate-term-governance is a type of memory that is a ‘*necessary precondition for mastering the complexities of human cognitive-cultural networks*’ (Donald, 2007, p.221). Figure 7.7 schematically illustrates the approximate temporal ranges of stable neural traces that support perceptual binding, short-term working memory (ST-WM) and intermediate-term-governance (ITG), adapted after Donald (ibid, p. 221). It is presented in relation to the average range for approximately 700 exemplar gestures enacted from Condition A, the charade game. They were contributed by the same neuro-atypical adolescent male who contributed exemplar for Case Study 1 (NAT-CP9). Time data were provided from the child gesture corpus, with kind permission of Roy (1996), see Panayi (2012) and Panayi (in prep). These two aspects of gestural flow and slow process are discussed further in Chapter 8 in the context of gestural dynamics.

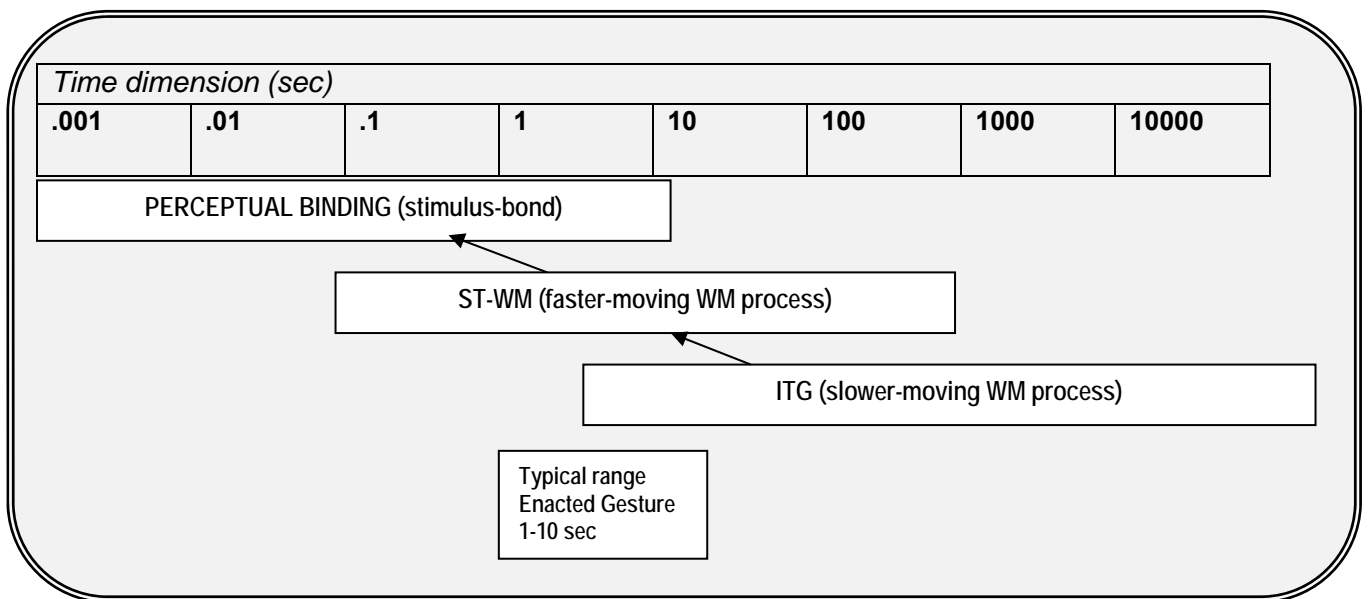


Figure 7.7 ‘Cognition-in-Action’ as Slow Process. An Illustration of slow process time dimension for neuro-atypical charade gestures from a neuro-atypical adolescent male with severe speech and motor impairment, see Panayi (in prep).

7.7 Summary

Corporeal Dynamic and Narrative Analyses and the Cognition-in-Action Framework

I have provided qualitative evidence that intentionality of the action embodied in child gesture enaction can be revealed by applying the G-ABAS, guided by G-IPA questions. Such a fine-grained and layered analysis of specific feature patterns provides evidence that instantiated aspects of children’s Cognition-in-Action. My analyses have shown that both

global (macro) and micro affordances can be coupled with human capacity to generate imagery for simulated (covert) gesture {GA-SA} and executed (overt) gestural action {GA-EA}. These capacities provide the foundation for corporeal enaction. Importantly, analyses of these exemplars illustrate how neuro-atypical young people have the potential to be able to momentarily compensate for their cerebral palsy at some level. They are able to perform controlled complex, asymmetrical/ symmetrical and bimanual gestures. This latent ability is present despite highly variable movement profile, exclusitory attitudes and severely compromised opportunities for physical interaction with the real (veridical) world.

I have shown that interaction methodologies that facilitate gestural narratives in particular, provide a rich environment for the exploration of such complex emergent action. I illustrate the potential for scoring, evaluation and validation of the G-ABAS and G-IPA tools. I also illustrate how by combining the annotation interpretative questions I am developing the (SKIP) that will be evaluated in the field. This forms part of my ongoing work. The expressions of latent abilities by young co-participants in Case Studies 2 and 3 provided evidence and support for the second aim of my thesis. These abilities have significant implications for the third aim of the thesis. However, the severely constrained neuro-atypical profile of the young people means that they often have reduced opportunities for interactions with the veridical world and social others. In terms of the construct of gesture-as-action within a biological system, these constraints may be described as operating across physiological, cognitive and social levels. A further detailed investigation of these constraints falls beyond the scope of my thesis. These analyses provide evidence to support the effectiveness of my interaction methodology and the validity and robustness of my annotation and interpretation tools. Furthermore, the C-i-A framework suggests that the presence of these corporeal dynamic and narrative features can be used to infer the integrated, highly interconnected and adaptive nature of the subsystems that underlie spatio-temporal and biosemiotic capacities of neuro-atypical child gesture. This postulated supramodal neuro-dynamics of the C-I-A framework is revisited in Chapter 8.

Chapter 8 Discussion

In this chapter I discuss the main themes and issues that arise from my work. I address Objective 7: *To identify the practical utility of the gesture-based annotation and interpretative phenomenological analysis tools within the Cognition-in-Action conceptual framework.* The chapter is presented in five sections. In section 8.1 I briefly summarize *the significant research gaps that I have identified and their implications in the context of my research.* In section 8.2 I *return to the work plan of my thesis that addresses the need to both re-think theoretical foundations and to develop tools and guidelines that can support research in the field of gesture studies,* and more broadly in the cognitive sciences. In section 8.3 I *revisit the C-i-A framework in terms of my key findings.* In section 8.4 I discuss how I can *instantiate levels of system dynamics within the framework.* I focus on two major aspects: *intentionality* and its *interpretation.* I discuss the *bringing forth, carrying forward and cultural embodiment* of Cognition-in-Action. The chapter ends with a *summary* of the implications of my findings and outcomes 8.5.

8.1 Significant Research Gaps and Implications

Working with young people with cerebral palsy enabled me to share some of the everyday experience and issues that arose from their determination, frustration and creative capacities to communicate, learn and interact physically with the world. My academic work began by looking beyond the clinical and pedagogic diagnosis of cerebral palsy as a movement and deficit disorder.

What follows in this section is an overview of major themes and issues. I discuss these in the context of the significant research gaps I identified, together with their implications for my work. I identified not only academic research gaps, but also issues that arise from clinical, pedagogic and technology design practices related to working with young people with Cerebral Palsy (CP). These have been discussed in detail in Chapter 2.

8.1.1 Efficacy of Existing Clinical Practice and lack of Theoretical Models

One of the major issues that became evident through my literature review was that there is significant concern with regard to the efficacy of existing practices. This is seen for example in the physiotherapy and speech and language interventions practices for young people with cerebral palsy. The implications of this have been

highlighted recently by seasoned researchers in the field of motor control, including Rosenbaum (2013). Rosenbaum makes the argument that there is an urgent need to re-think not only our practices per se, but perhaps more importantly, the theoretical grounding of these practices.

8.1.2 Mechanisms of Neuro-biological Action

I re-examined the literature in the domains of the neuro-biology of action and language and juxtaposed my re-conceptualization alongside conventional reductionist conceptual frameworks. My re-conceptualization has now become timely as researchers who focus on understanding conventional models of perception, cognition and action have also begun to reconsider their adequacy. A case in point is the pivotal role played by the influential mirror neuron system (MNS) hypothesis. In such models both motor control and language are considered to be driven by higher level, brain bound processes. The earlier debates included those who saw MNs as innate structures, see Rizzolatti and Arbib (1998). Most recently, the roles played by sensorimotor experience and sensorimotor contingencies are being revisited by several authors. The clinical implications that the neuron system (MNS) is a key mechanism involved in understanding the other's actions and intentions in terms of *observational learning*, and *associative learning* were also considered.

However, what is most relevant in the context of the C-i-A framework is a broader reconsideration of MNS function as part of the supra-modal system. Such a system is influenced by our multi-sensory interactions, tool-use and nature of empathy involved in action. Examples of work that supports these propositions can be found in Ricciardi et al. (2013) and Vecchi (personal communication, 2014); they present evidence from both sighted and congenitally blind subjects during visual and/or auditory presentation of hand-made actions that endorse the supra-modal nature of perception-cognition and action. Furthermore, Oyama (1985/2000) argues that we should go beyond the nature vs. nurture debate to embrace a developmental system theory, a new vision for the processes of development and evolution.

8.1.3 Revisiting Language and Gesture

Furthermore, researchers in linguistic communities who examine acquisition and development of spoken and manual languages are also advocating a re-examination of traditional, representational models. Vigliocco et al. (2014) suggest that speech and non-verbal communications should be seen as multi-modal

phenomena. Similarly, Beilock and Goldin-Meadow (2010) re-examine gesture in action contexts.

Newer perspectives are emerging that advocate a broader ecological framing for our communicative interactions as *linguaging*, as discussed by Bottineau (2010). More radically, Cowley (2014) suggests that language can be seen as a process of *wording* that evolves within an ecologically distributed cognition framework.

8.1.4 Implications for Child Gesture Studies

Taken together these findings are also supported by recent trends in child action studies that argue for a reconsideration of the role of action, the body and artefacts in the development process. For example, the work of Thomas et al. (2009) re-emphasises the developmental process as being dynamic in nature. Reddy (2008) has argued for the importance of examining 1st person perspectives during interaction. The relevance of real-world objects in infant interaction and learning is reconsidered by several authors, including Sinha and Rodriguez (2008) and Smith et al. (2011).

From neuro-physiological perspectives, Sommerville and Woodward (2010) have considered the neurological implications for infant action learning in relation to social interactions. Furthermore, Schilbach et al. (2013) put forward arguments that understanding the underlying neural mechanism of *second-person perspective* is fundamental to understanding these real-time social interactions. They use astro-biological metaphors of cosmic life to describe the experimental *landscape*. They go on to argue that where dynamic interactions come together with experiential participation is an area of *dark matter*, (p.399, *ibid*). These studies are illustrative of the increasing relevance of action based, embodied, extended and enacted approaches to human development and learning. Within the C-i-A framework I endorse two specific arguments: *Firstly, that conventional linguistic frameworks for understanding gesture are no longer sustainable*, see also Kendon (2014) and

Secondly, that we need to revisit the ideas of developmental processes and enacted interaction processes, more specifically as eco-social, see Lemke (2000) *and dynamical complementary systems*, see Kelso (1995 and 2006).

8.1.5 New Avenues

However, although the majority of theoretical frameworks where they exist still rely heavily on reductionist thinking, there are promising new avenues. I have discussed two: one is the enactivist paradigm and the second is the application of dynamic and more specifically dynamical system methodologies, such as dynamical field theory (DFT), to the investigation and explanation of enacted developmental and higher cognitive functions. Here I cite two examples of the application of the latter: Clearfield et al. (2009) applied these explanatory frameworks for an investigation into infant reaching and Sandamirskaya et al. (2013) use the methodologies to extend the embodied stance towards higher cognition of autonomous robots. I have begun to apply DFT within the notion of Cognition-in-Action as part of my more recent (Panayi, 2010) and future work, see Chapter 9.

8.1.6 Paucity of Research and Practice Data

It should be noted, however, that across all these domains there is still a paucity of research and practice data that consider the diversity of human interaction. This is particularly evident in the case of young people aged between 5 and 18 years who have severe speech and motor impairment due to cerebral palsy, i.e. at levels IV-V. Thus, the research gaps I identified carry with them significant implications for our work with neuro-atypical populations. In the following section I revisit and discuss my work plan.

8.2 Work Plan

8.2.1 Need to revisit theoretical foundations

The overall structure of work in my thesis was guided by *Biological Systems Theory* (BST) which I propose as the best candidate for framing my investigations. This interdisciplinary approach enabled me to examine and synthesise theoretical and empirical evidence from the domains of *Philosophy*, *Science* and *Technology*, including relevant arenas of *practice*.

My work set out to contribute to the re-interpretation of the intentionality of human interaction as expressed through young people's gesture. I began by deciding to explore how young people diagnosed with severe speech and movement impairment could use corporeal gesture expressively. I place this work within the context of the extant literature (Chapter 2) and in section 8.1 the emerging paradigm

shifts at theoretical and empirical levels in the research domains of gesture studies, cognitive neuroscience and clinical practice.

From the philosophical perspective I was influenced by Husserl, Heidegger and Merleau-Ponty and their approaches to the *phenomenology of intentionality*. In re-thinking the nature of our corporeal action I took inspiration from the physical aspects of the art of oratory. I examined this art form from antiquity to contemporary practices in the performing arts, specifically, physical theatre, corporeal mime and dance. I also drew upon narrative theory.

My synthesis provided validation for the need for novel frameworks; it endorses the work of Bouissac (2004) who suggests that:

'high-level or general theories are still missing. There is indeed a lack of theoretical perspective within the whole range of what is known about human movement, from biomechanics (e.g. Berthoz 2000, Vogel 2001) to semasiology (e.g. Williams 1982) would be accounted for in a comprehensive, albeit complex manner. It would be exhaustive, consistent and predictive.' *ibid.*

My interdisciplinary methodology was inspired both by philosophical and biologically grounded perspectives, rather than conventional psychological methodologies. I began by endorsing phenomenological methods as being better able to accommodate third person observations of 1st and 2nd person perspectives. Varela and Shear (1999) emphasise the need for 1st person methodologies and describe human experience as phenomena that are not fixed or delineated, but *'changing, changeable and fluid'* (*ibid.*, p.14). These perspectives are consistent with the Csíkszentmihályi et al. work on experiential flow (1988 and 2005) and the Arzubiaga et al. work on ecologically valid practices (2008). Furthermore, Varela and Shear propose that phenomenal data are *'valid intersubjective items of knowledge'*. This amongst other work informed the development of the theoretical and empirical outcomes of my own work.

I was able to derive a *'neurology of gesture'* that supports the supra-modal nature of intentional action expressed through gesture (Panayi, 2001). I later highlighted the importance of the role of spatial cognition in action both at the interactional level (Panayi, 2005) and at the cellular and organism levels (Panayi and Roy, 2012). Interestingly, Walther et al. (2011), studying neural correlates that underlie the phenomenon of *inhibition*, argued that core executive function is supra-modally organized. Such arguments are illustrative of those that continue to influence and justify my rationale for reconsidering both theoretical frameworks and empirical

evidence when considering the neuro-atypical systems of young people with cerebral palsy.

I went on to propose *Cognition-in-Action (C-i-A)* as the central construct for a novel conceptual framework for re-thinking the ephemeral phenomena we call gesture. I offer this re-conceptualization as an alternative non-representational framework.

In summary, my conceptual framework challenges the adequacy of reductionist theoretical frameworks and consequential empirical research to apply sufficient explanatory power for the description of dynamic interaction processes. Furthermore, such conventional research is currently unable to be inclusive of heterogeneous inter-actors or accommodate explanations at a systems-level.

8.2.2 Need for Tools

8.2.2.1 Returning to the Child Gesture Corpus

The Child Gesture Corpus was established from the contribution of young people with cerebral palsy see Roy and Panayi (1991). These exemplars provided data for the computer recognition of dynamic arm gesture in neuro-atypical children using artificial neural networks (ANNs) see Roy et al. (1994 and 1996). I later added to corpus when neuro-atypical and neuro-typical children contributed gesture repertoires from two further projects. The first was a performance arts and technology project, *Body-Tek: A Digital Body*, see Panayi (1995) and Panayi and Roy (1998). This involved the camera capture and mapping of intentional movement to music and the incorporation of such movement into physical theatre scenarios. The second contributions came from neuro-typical children involved in ludic games and interactions that focused exploring technology design challenges, including the design of Wearables see Panayi et al. (1998 and 2000). Only neuro-atypical exemplars from young people with cerebral palsy were presented in my thesis.

8.2.2.2. Three Case Studies The challenges

Previous manual segmentation of gestures captured on video and with some movement data used a simple three level categorisation of gesture prior to computer recognition, i.e. *static*, *dynamic* or *pose*. Body part involvement was also documented. The Child Gesture Corpus contains exemplars that needed further finer grained analyses. However, despite advances in gesture studies and the use of computer based

analysis software, existing topologies were found to be lacking. Significantly, they could not be applied to atypical gesture repertoires.

This justified and necessitated the development of two new tools. Three case studies from neuro-atypical young people with cerebral palsy provided the exemplars selected for presentation and analysis in my thesis.

8.2.2.3 New Tools G-ABAS and G-IPA

As well as identifying research gaps at a theoretical level, I also identified methodological research gaps within gesture studies and allied fields. I have shown that there still remains a paucity of analysis methodologies and tools that can provide comprehensive annotation ontologies that are both inclusive and interpretative. That is that can provide insights into both the neuro-atypical and neuro-typical movement profiles of children in their life worlds. This necessitated the development of two tools. My overall discussion of the challenges, advantages and limitations of developing empirical tools for the analysis and interpretation of gesture can be found in Chapter 4.

This discussion places the body-based gestural action annotation system (G-ABAS) and an Interpretative Phenomenological Analysis method adapted for gesture (G-IPA) within the context of their utility in supporting the investigation of open research questions. Together they provide a much needed ontology of intentional action and a means to begin to interpret sense-making processes that unfold during our situated interactions.

The G-ABAS tool goes beyond conventional linguistic ontologies for gesture. This thematic body-based action annotation system has the capacity to annotate in the region of 260 features across two strands: *corporeal dynamic* and *corporeal narrative*. Each major strand is arranged in five themes with sub-ordinate clusters. These categories can be used to inventory dynamic action.

The Interpretative Phenomenological Analysis method (typically used for the analysis of text), is adapted and applied for the first time to interpretation of corporeal action. I chose this phenomenological approach to explore the subjective nature of intentionality. G-IPA questions can be iteratively integrated with the annotation process. These tools exhibit greater sensitivity to a range of features within gestural phenomena.

8.2.2.4 Utility of Theoretical frameworks and Empirical tools

I have illustrated the capacity of these two new tools to guide the interpretation of intentional action together with the C-i-A framework at four levels of system complexity. Briefly these are described as: 1) *random dynamics*, e.g. no discernible pattern; 2) *simple dynamics*, e.g. stable and connected patterns; 3) *complicated dynamics*, e.g. dynamic patterns across system levels may be present (with self-correction); and 4) *complex dynamics*, e.g. dynamic patterns that can be adaptive/co-evolving with each other and the environment that are interdependent, nest webs and networks. These system levels of complexity are illustrative of a self-organizing, autonomous and precarious system with capacity to learn and change see Chapters 6 and 7.

Thus, the Cognition-in-Action conceptual framework and empirical tools have utility firstly in the field of gesture studies, and secondly, more broadly in the field of cognitive science and the development of artificial cognitive systems. An example of the potential use is in the advanced understanding of human motion.

For gesture studies they can be used to code and for the inventory of gestural action. They can be used for both *utilizing reliability*, i.e. coder's ability to agree on observed gestural units, and for *classificatory reliability*, i.e. level of agreement on unit classification. Uniquely my tools can clearly be used for the examination of outliers, i.e. they are suited to heterogeneous data and can be adapted to different contexts. There is inbuilt capacity for triangulation, i.e. number of sources and observers with capacity for further sub-themes to be added and/or modified. Finally, such work has utility in producing data to inform larger studies and studies across different disciplines. For an example of use in the preservation and transmission of intangible cultural heritage, this forms part of my work for a future paper.

In the field of cognitive science and the development of artificial cognitive systems attempts are being made to not only understand the nature of human action, but to simulate it and embody aspects of responsiveness into tangible, material artefacts. Such artefacts are increasingly being embedded in, for example, our homes, public spaces and learning environments, including those that support assistive living. Robotic platform developers are focussing efforts on creating artefacts that have the capacity to build relationships with their human inter-actors, including people who are conventionally considered to have neuro-atypical profiles. Further examples include the development of products for the rehabilitation and care sectors.

8.3 Revisiting the Cognition-in-Action Framework

8.3.1 Action-Ready-Body Mediator of Intentionality

Re-stating the definition

In revisiting the C-i-A framework, I begin by restating my extended definition of the ephemeral phenomena we call gesture as a:

dynamic system, where intentionality is brought forth, carried forward and both embodied and extended through our interactions with the social other and the other as artefact.

This definition places the *Action-Ready-Body* centre stage. It is where intentional action enacted through gesture is at the nexus of our interaction processes, our lived experiences. I took Maturana and Varela's biological approaches as my reflective starting point. They introduced the term autopoiesis, i.e. *an organism that sustains its systemic self-renewal with an operationally coupled and closed system*. Bateson later developed their notion of action within the system introducing a definition of *knowing as doing*. It is from here that I re-considered gesture as one aspect of our autonomy where movement is *bounded, self-organizing and precarious*.

The Cognition-in-Action framework has the capacity to describe properties of the natural system where gesture Θ is considered within a dynamic, bound system. Three fundamental capacities are described by the terms θ^1 , θ^2 , and θ^3 which are re-stated in Box 8.1 below.

- ❖ θ^1 *The conception, access and control of body action schema of the self, social other and the other as artefact.*
- ❖ θ^2 *Use of underlying mechanism supported by supra-modal organic coding for the representation of action across multi-sensory space and time*
- ❖ θ^3 *Ability to execute dynamic transitions between the physical (i.e. veridical and material) and conceptual world*

Box 8.1 Gesture terms described in terms of children's capacities

Corporeal gestural interaction flow underlies sense-making processes where knowledge can be described as Gesture-Action-Entity (GAE). Three main types are considered: *procedural* (P-GAE), *semantic* (S-GAE) and *episodic* (E-GAE): this knowledge is corporeally embodied within our gestural intentionality.

I chose the biological metaphor of ecological niches, i.e. '*the ecology of interaction*' to contextualise both the phenomenology of intentionality and the notion of corporeal embodiment. Here the relationship of the actors within those ecologies can be described as those with the *self* and the *other*. The other can be a social other and/or the other as artefacts see Panayi and Roy (2005). These ecologies extend

beyond *material space and time* to include the *imaginary* and the *hybrid*. These interactions are core to our human ability for *sense-making* in our veridical, imaginary and hybrid worlds. Hybrid space-time bridges the veridical and imaginary. These ecologies may include technological artefacts that increasingly contribute to the blurring of the boundaries of presence; see Roy et al. (1993); Panayi and Roy (2005).

In the C-i-A system architecture I revisited the notion of imagery and reconsider Gendlin's argument for an alteration in our assumptions of what we mean by imagery, restated here. He advocates a shift from imagery being *representation* to it being embodied experience, i.e. *bodily change* that lives an *image event*. That is imagery as being a '*special kind of bodily living in an environment.*' These images or image-events can be the source of what he calls '*felt-sense*', influencing '*holistic body change*'. Furthermore, his description of the body can be interpreted within biological system theory, where the body is '*an interactional process so body emotion, situation, action, and other people is always inherently a single system*' (Gendlin 1980). In addition, Gendlin suggested that contents can arise both through bodily processes and changes within these processes (1981). For him, humans are 'capable of an immense variety of kinds of processes and thereby also kinds of 'self', kinds of 'contents' and kinds of observable results' (ibid, p.237). These kinds of selves and contents are revealed by my analyses and interpretations of cerebral palsy gesture see Chapters 6 and 7 and section 8.3.2 below.

I endorse and develop these notions within the C-i-A framework where the gestural system is bounded. Such notions of consciousness and imagery are operationalized and described as levels of encoding and decoding. They unfold at both *endo-semiotic* and *exo-semiotic* system levels; see Panayi and Roy (2012).

In summary, I focused on how underlying intentionality of action could be *brought-forth, carried forward, captured, analysed and interpreted.*

8.3.2 Key Findings and Outcomes

The tools discussed in 8.2 were successfully applied to the analyses of gestural exemplars from the three case studies. The young co-participants who contributed the exemplars have neuro-atypical profiles resulting from severe speech and motor impairment (level V) due to cerebral palsy.

They were non-ambulatory quadriplegic wheelchair users. They are described as ‘*augmented*’ speakers; their speech was dysarthric and they used external communication aids. They relied on carer and parents for their everyday living needs. They had no significant previously documented gesture repertoires. Their profile descriptions are consistent with the conventional perception of the capacity of such individuals.

However, the generative design of the ludic interactions provided opportunities for movement through gesture. The design paradigm was inspired and informed by social, biological and performative models of interaction.

My re-examination of specific gesture exemplars from neuro-atypical young people served to illustrate a) the *latent capacities* for corporeal action in sense-making context; b) the *supra-modal strategies* that underpinned these capacities; c) suggested the potential to *explore and exploit heterogeneous individual pathways* to develop these coherent, consistent capabilities; and d) made possible the *inference of sub-system interactivity*, i.e. a provided a window on the system-level organization of intentional action.

The initial analyses revealed the *latent capacity* of young people to *self-initiate, inhibit, control and modify* their *intentional acts* during the ludic interaction scenarios in which they participated. This was in contrast to previously documented medical diagnostic descriptions of *lack of control* and *involuntary writhing* movement profiles.

Further in-depth analyses of these exemplars reveal that these co-participants were able to *abstract action, select salient aspects* of the action to enact and use a range of *performance strategies*. Importantly, these performance strategies included the ability to *modulate their enactions on the fly*, i.e. showing an ability to improvise action. The *charade game scenario* provided opportunities for the co-participants to reveal a significant range of procedural knowledge, i.e. *corporeal dynamic features* that were enacted within their *gesture sphere*. These intentional acts unfolded across

microgenetic time and space and ranged through *peri-personal, allocentric* and *far space*. In the scenario that involved *co-construction of narrative*, the young person revealed what have been described as sophisticated '*performance strategies*'. This could involve *another* that is *socially present* and the *other(s)* that may be *imaginary*. In addition, they were able to evoke *imaginary objects* they could both *interact* with and *manipulate*. All enaction could be described as, being *coherent* and having *consistent* qualities. These enactions involved *making the invisible visible*.

In summary my tools have the capacity to examine embodied happenings, i.e. expressive actions conceptualized as gesture entities. These may reflect the present environment, i.e. embodied or veridical, or be displaced, i.e. not physically present, perhaps in the imaginary or even notions that are non-existent.

One overriding interpretation was that these enactions reveal how the young person could: a) *access their prior knowledge of the world*; b) *be influenced by affordances* and c) *bring these skills to bear on their moment-to-moment interaction*, i.e. bring forth and carry forward their corporeal cognition. These capabilities were in marked contrast to the historic descriptions of the physical constraints that underlie their motor impairment. Significantly these gestural capacities had not previously been documented.

8.4 Instantiating Aspects of C-i-A

Dynamics of Intentionality and Interpretation

My interpretative findings were used to instantiate aspects of the C-i-A framework where the *Action-Ready-Body* is placed centre stage and I examine the *bringing - forth, carrying-forward and potential cultural embodiment* of intentional action in gesture. These are discussed in the sections that follow.

8.4.1 Bringing-forth Dynamic Couplings Mediated and Augmented

Stability, Instability and Plasticity

At a philosophical level I was influenced by Merleau-Ponty's notion of mutual interaction that supports stability and the possibility of the novel. Within the C-i-A framework gestural system intentionality can be modified at a motoric level and thus be influenced by mutual interaction and be adaptable to the novel. Operationally this can provide a mechanism that links *behaviour* and *plasticity*. In contemporary terms, this is consistent with neurological research that examines motor control in infants

with CP (for examples see Heide and Hadders-Algra, 2005, and Kerkhoff and Rossetti, 2006, for recovery in rehabilitation context).

Dynamic Coupling

My empirical study illustrated the potential power of dynamic *coupling* during ludic interaction. Despite limited physical interaction opportunities with the veridical (real) world, neuro-atypical children and adolescents with cerebral palsy have the capacity to access latent resources and express emergent corporeal gestural abilities.

In Figure 8.1 a) I represent a visualisation introduced by Maturana and Varela (1992) that introduces the notion of *autopoiesis* (see section 8.3.1). The figure illustrates the dynamic situated interaction between two neuro-typical unities. However, their model does not consider heterogeneous inter-actors. Waves represent the environment; two-way arrows the interactions with others and the environment. The ribbon arrows indicate the wider ecological system. Internal cyclic arrow indicates the internal dynamics that are constitutive of the dynamics at surface interaction.

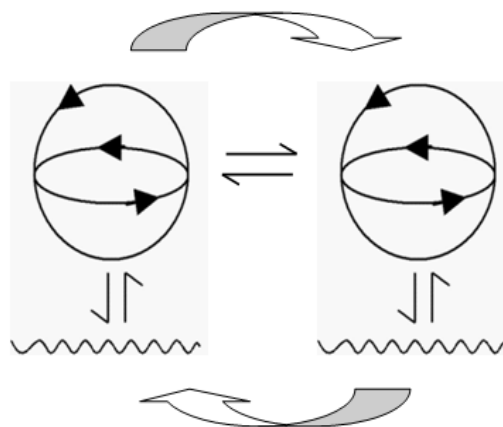


Figure 8.1 a) A schematic illustrating the dynamic situated interaction between two neuro-typical unities, original symbolic notation is adapted after Maturana and Varela (1992).

Neuro-atypical and Neuro-typical Interaction Couplings

In the C-i-A framework I have adapted this visualisation to illustrate how it can support the explanation of coupled interactions between individuals with very *diverse capacities for adaptation*. This is shown in Figure 8.1 b); it illustrates the dynamic situated interaction between a *neuro-atypical* and a *neuro-typical* unity. The sphere to the left denotes a neuro-atypical co-participant with their associated

subsystems and interactions with their environment (broken lines) and social *others*, also denoted by broken lines.

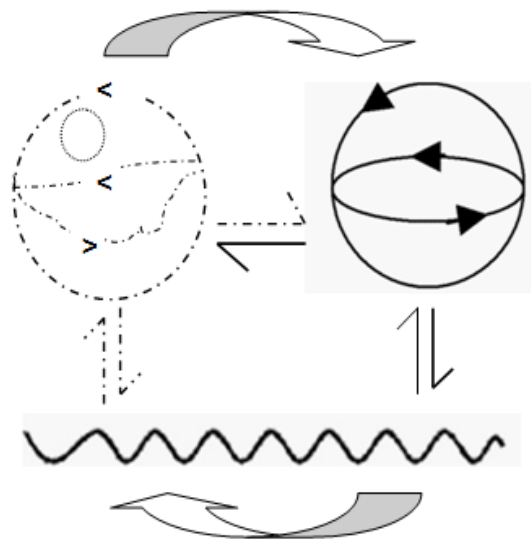


Figure 8.1 b)
Neuro-atypical and neuro-typical unity coupling

The internal sphere can denote aspects of memory such as *recall*, *reflection* and types of *imaginaries*. In conventional terms, imagery processes are based on representations that are simulated or emulated. Within the C-i-A framework I use Gendlin’s terminology that describes *holistic body change* arising out of ‘felt-sense’ as underlying *image events*, and I align these to the intentionality of gesture. Firstly, intentionality drives the *bringing-forth* of gesture which can then be *carried forward*, e.g. through transformations including improvisation.

In such *bio-social systems* the unities may be operated within constraints, e.g. severe speech and motor impairment due to cerebral palsy. Despite these constraints interactions can be achieved. Such interactions can have features that can be described as *flow*, *motor resonance* and *empathy*.

Mediated and Augmented Couplings

I have discussed how these interactions may be mediated by the material, e.g. the physicality and tangibility of tools or toys. For a historical treatment of tools and gesture, see Gourhan (1993). Similarly, Hutchins (1995 and 2010) discusses the importance of the physical artefacts in work interactions. The Goodwins (2000) investigate the resources and configuration of the materiality of play. On robotic technological platforms, Di Paolo et al. (2010) provide a discussion on how such concepts can be embodied within robotic platforms.

In Figure 8.1 c) the C-i-A framework illustrates the complexity of dynamic and situated interaction between a *neuro-atypical* and *neuro-typical* unity. In this case the interaction is *mediated* and *augmented*, denoted by (S). *S* is considered the social *other*. For the case studies presented in my thesis the co-participating researcher and therapist (where present) are free to mediate and scaffold the interactions. Where interaction is mediated or augmented by *artefacts*, including technology, this is denoted by (S_t). This sphere of influence is denoted as interactive, i.e. arrows within the dotted ellipse.

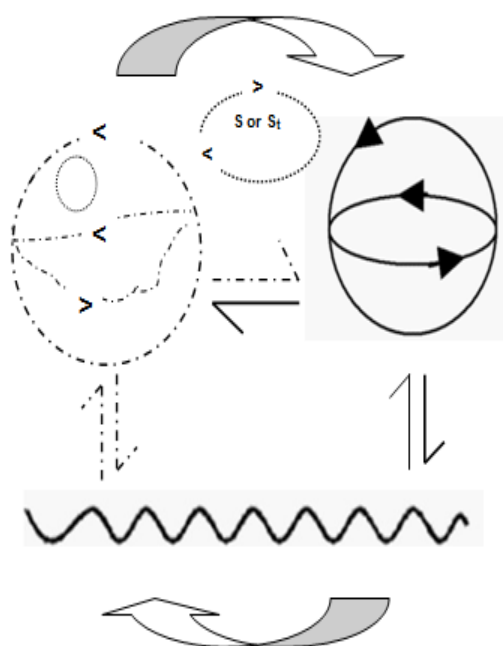


Figure 8.1 c) Mediated and Augmented Couplings

8.4.2 Carrying Forward and Cultural Embodiment

In this section I illustrate how *spatio-temporal phases* are instantiated and inferred within the C-i-A framework. Maturana and Varela (1992) describe how actions are *brought-forth* and Gendlin (1980) describes how experiences are *carried forward*. Donald (2007) discusses extensively how humans may experience their worlds across *microgenetic*, *ontogenetic* and *phylogenetic* timescales. He has proposed a form of intermediate memory that supports interactions that extend our social presence, e.g. through our narrative and game playing skills.

I have considered the spatio-temporal importance of our social interactions in terms of the analyses of gestures from the repertoires of young people with CP. I have

illustrated how they are *brought-forth* in *microgenetic time and space* and range through *peri-personal, allocentric* and *far space*.

Importantly, the scale of human action that we perceive unfolds at the second and millisecond level of neuronal processes. Of course the biochemical level processes can happen even faster, as well as higher level processes that are usually imperceptible. For the gestures analyses in my thesis I consider how these interactions unfold across veridical, imaginary and hybrid worlds and infer how they are carried forward and can potentially be culturally embodied see Chapter 7.

The interactions described by Figure 8.1 take place in the *microgenetic phase* of the system. In Figure 8.2 I illustrate how intentionality *bringing-forth* is *carried forward* and potential embodied in our *cultural heritage*. This aspect of my work is the subject of a forthcoming publication. Here they are summarised in relation to interactions that are inferred to take place in the *ontological* and *phylogenetic phases*.

Microgenetic Phase

The microgenetic phase of the system shows the non-linear dynamic, autonomous and self-regulating systems of intentional action. The process involves *moment-to-moment flow*. The flow can be operationalized through system analysis at the cellular, multi-cellular and social levels. In this phase of my analyses I focused on the social level. These recurrent interactions lead to *social coupling* and reciprocal co-ordination. In turn these result in *structural congruence* between two or more systems.

Unities A & B are life forms that *bring forth* action from their *intrapersonal corporeal self* and/or *intercorporeal action* with the *social other* including *artefacts*. These intercorporeal interactions give rise to *phenomenal domains*, e.g. early communication, including development of gestural capacity and language through '*languaging*', *play*, *tool use* and *artefact building* including technology. These domains embody reflective and sense-making phenomena, which arise from interaction with *bio-semiotic resources and structures*. These resources and structures are individually created or co-created within the unities ecologies. This phase can lead to a *meso-genetic* phase that can encompass extended activities such as play and performance.

Ontogenetic Phase

The ontogenetic phase involves recurrent interaction with social coupling leading to *progressive reciprocal co-ordination*. Over developmental time, this may result in further structural congruence between two or more systems. This can give

rise to further development of more sophisticated, complicated and complex phenomenal domains expressed across the individual *life span* and *inter-generationally*.

The interactions can take place within our veridical (real), imaginary and/or hybrid *spaces*. These spaces are our *life worlds (LW)* where our lived experiences (*SLE*) unfold, are carried forward and become culturally embodied. Co-ontogeny represents a history of mid-range (life span) cultural activity and co-existence within the bio-ecology life worlds.

Phylogenetic Phase

Phylogeny within the system represents a history of long-range cultural activity co-existence in life worlds. These timescales involve adaptations to ecological system change that in turn may impact on the genome and can be expressed through the phenotype. Evolutionary adaptive phases are described as timescales (epochs) that incorporate natural *drift*.

Operationally for the C-i-A framework the connectivity of the subsystems across microgenetic, ontogenetic and phylogenetic phases provide the potential for change within the system. This comprehensive description of the C-i-A framework highlights that such bio-social structures have the capacity to arise developmentally in relation to both genetic maturity and ecological interaction.

8.4.3 Implications for an Action-Ready-Body

The implication is that this offers opportunities for developmental intervention. The C-i-A conceptual framework and associated tools could be used to identify, capture and harness emergent corporeal capacities that could inform future interventions designed for young people with alternative developmental including movement trajectories. These young people could then choose to work with others to affect their own system change, through the development of their Action-Ready-Body.

8.5 Summary

Significance and Implications of findings and outcomes

My findings informed a novel system-level theoretical approach to the development of a conceptual framework for intentionality embodied as action. I have argued that it is better suited to supporting a deeper understanding of the ephemeral

phenomenon we call gesture. These findings together with their interpretations highlighted the need to re-think how we conceptualise gesture in children, particularly those with diverse movement profiles. The underlying system processes for cognition are not only complex, dynamic and non-linear, but also clearly able to support emergent behaviour and the development of future skills and habits.

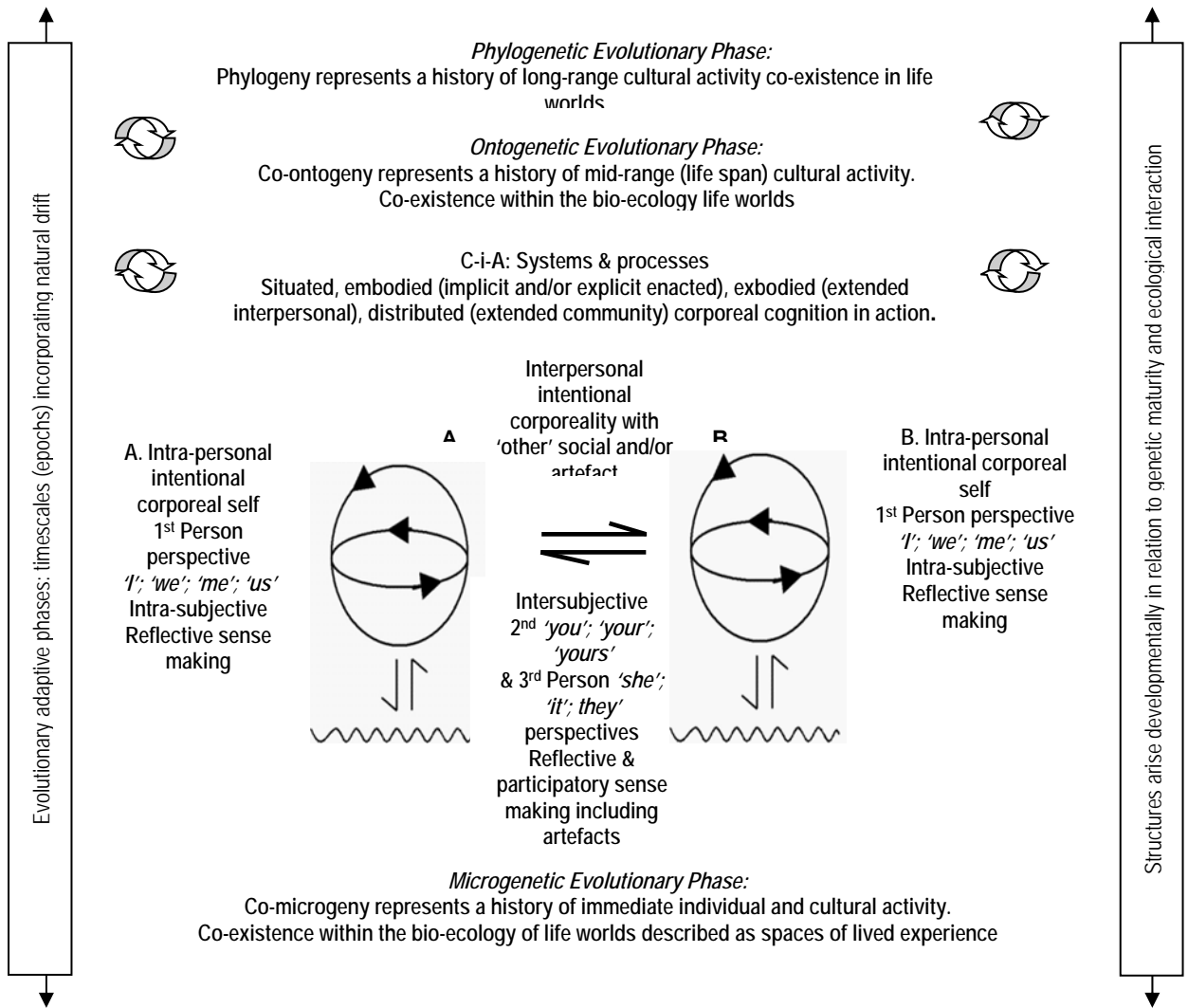


Figure 8.2 Schematic of the Cognition-in-Action (C-i-A) conceptual framework in terms of microgenetic, ontogenetic and phylogenetic phase. Key: Evolutionary Phases, Life forms (A & B) and Spaces of Lived Experience (SLE). Circular arrows in the corners of each phase indicated phase transitions.

The major advantages of my tools are that they can be applied inclusively to both neuro-atypical data (my thesis) and neuro-typical data (reported elsewhere, see Panayi, 2011). My fine-grained levels of analyses go beyond conventional annotation ontologies typically used in gestures studies. The Interpretative Phenomenological Analysis was adapted and applied to gesture for the first time. In order for my

findings to be generalized, further work is needed. However, these findings can be used to inform larger studies, future interventions and design practice.

Importantly for this study and particularly for neuro-atypical children, the framework illustrates how gesture can be driven by motivational context even in physically compromised or constrained systems. I propose that dynamic processing within our gestural system involves a type of organic representation, transformation and inhibition of movement, particularly in the case of neuro-atypical movers. I have put forward arguments that this dynamic processing can transcend individual sensory modalities, i.e. is supra-modal. The evaluation and validation of the C-i-A framework has focussed on the corporeality of gesture in terms of the motor dynamics and strategies of intentionality made visible by the co-participants in ludic interactions. I considered the validity and utility of the framework by progressively examining aspects of embodied dynamics at a system levels that are able to exploit the '*Action Ready Body*'. My research contributes original knowledge and is a timely contribution to the fields of gesture studies, health sciences and cognitive science. Significantly, the C-i-A predicts the importance of *motion saliency* in the *selection, manipulation, transformation, modification, sustainability* and *stabilization* of dynamic intentional action. However, for young people with CP, physical and verbal interaction in the veridical world is compromised. They do not learn about *reaching, holding* and *grasping* through real-world experiences. They need augmented devices to communicate. I have argued that within the C-i-A framework levels of *social engagement* and *opportunities for corporeal cognitive knowledge transformation and manipulation* may be the critical factors in enhancing learning see Panayi and Roy (2012). These key findings and interpretations provided insights for new developmental psychology models of gesture interaction. The framework furthers our understanding of the underlying mechanism that enables neuro-atypical children with severe speech and motor impairment to gesture, transform their knowledge, and participate in sense-making activities. In the Chapter 9 I summarise my novel contribution to the field of gesture studies and more broadly to cognitive science. As part of my future work I have identified that there is potential to extend the explanatory power of my qualitative conceptual framework using mathematical modelling (see Panayi, 2010). I reflect on some of the open research questions that remain within the context and the development of future practice paradigms in the clinical, rehabilitation, pedagogic and intelligent design sectors.

Chapter 9 Conclusions

In this chapter I revisit the aims and objectives of my thesis, the outcomes of my findings and their contribution to knowledge, together with their implications for the stakeholders of the research. The timeliness of my research is set against the background of my critical literature review, the research I presented and the context of my ongoing and future work.

9.0 Crossing Boundaries

My research offers an original contribution to knowledge in the areas of gesture studies, movement science & applied participatory arts and health. The research began by focusing on and reconsidering the potential of corporeal expressivity in children and young people with severe speech and motor impairment due to Cerebral Palsy. My interdisciplinary approach provided both breadth and scientific exactitude to this area of study.

My overarching aim was to reconsider the nature of the physical, emotional and intellectual interaction of children and young people with Cerebral Palsy. The three aims of my thesis set out the remit for the development of a theoretical framework reconceptualising gesture and tools for the analysis of corporeal expressivity. This work was done in the context of examining the extant literature. I formulated seven objectives to guide my research. I used an iterative cycle of theoretical and empirical research for rethinking gesture and introduced the construct of Cognition-in-Action (C-i-A).

The mixed methods approach included single case studies that re-examined video exemplars from The Child Gesture Corpus (CGC) using the newly developed body based GABAS tool and Interpretive Phenomenological Analysis applied for the first time to gesture (G-IPA). These tools supported the fine-grained annotation of both dynamic and narrative features of intentional actions in 3-D gesture space.

The ludic game protocols, together with these tools, supported opportunities to explore both capability and potential development of capacity for corporeal gesture. The consistency of the movement repertoires supports the reliability of the analyses. Thus, my work provides an opportunity to enhance existing psychometric measures in both the research and practice sectors.

The purpose of this chapter is to recapitulate the motivation for my interdisciplinary research and its timeliness, and to summarize how my objectives were met: *The Why? For Whom?* and *The How?* - Section 9.1. In Section 9.2 *Meaning and Practical Implications*, I discuss the utility of my research and reflect on what these outcomes mean in practical terms for the stakeholders of the research. In section 9.3 *Next Steps* I consider how the predictive

power of the C-i-A framework, can be increased in the context of open questions and future systems thinking and practices. This chapter ends with an illustrative hypothetical future use case scenario of how this knowledge can be applied by practitioners, clinicians, parents/carers and the potential for use by our young people themselves.

9.1 Contribution To Knowledge The Why? For Whom? and The How?

9.1.1 The Why?

The Timeliness of Research

My thesis is a timely contribution to the current theoretical and practice discourses in movement science and health, gesture studies and applied participatory performance arts that examine the nature of human intentionality. More specifically, my work focuses on the corporeal expressivity of children and young people with severe speech and motor impairment as a result of cerebral palsy (SSMI-CP). My motivations for the research, together with the aims and objectives are presented in Chapter 1, together with an introduction to the basis of the theoretical framework.

When looking at corporeal expressivity of young people in particular, gaps were identified in both theoretical frameworks and practice. This aspect of the work was encompassed in **Objective 1: *To critically review existing frameworks and models of medical practice in relation to cerebral palsy children's action and gesture.*** This objective also encompasses the motivation for my interdisciplinary work that brings together theoretical and empirical research from the domains of: philosophy, cognitive neuroscience and technology to support a better understanding of children's corporeal cognition embodied in their enacted gestures.

My critical and contemporary review of extant literature in the domains of medical and clinical practices, neuroscience, including motor control and linguistic models of gesture, is presented in Chapter 2. I examine not only historical models of action, language and gesture, but also more recent trends towards interdisciplinary approaches to these studies. The corporeal gesture phenomena that I examine clearly go beyond the brain. The repertoires of children and young people who contributed to the Child Gesture Corpus are clearly social and unfold both at an individual and at a group level across microgenetic time scales. My thesis is timely, since conventional conceptualizations of language to which gesture has previously been historically bound, are also being rethought.

Similarly, from the phenomenological cognitive science arena, sensor-motor schemes are being revisited in terms of enactions. In the biological movement sciences, disrupted

motor actions are examined using new approaches. In the medical sector and with intervention therapies, new frameworks are being proposed, as are protocols for re-focusing on broader interpretations of participation. However, despite recent advances in theoretical thinking, the impact of such advances on practice still remains an issue. The research gaps were identified at both theoretical and practice levels in these domains.

The inter-disciplinary approach of my work allowed for *Biological System Theory* to be considered as the best candidate theoretical framework for exploring the complexities of inter-corporeality. As the best candidate structure, it grounds and facilitates the synthesis of my enactivist phenomenological approach. Recent work on intercorporeality in human interaction echoes the transdisciplinary approach of my thesis. As with my research, such work also draws upon Merleau-Pontian concept of intercorporeality that transcends the object-subject divide. It provides further insights from both theoretical and developmental perspectives including meaning-making in interaction and the importance of objects. The notion for an integrative framework is suggested in such work, but not presented.

I began by applying a dynamic systems and enactive sensor-motor lens to support more fine-grained observations and analyses of the situated embodied intentional gestural repertoires of children. I proposed the theoretical construct of Cognition-in-Action to emphasize the corporeal nature of intentional action. This provided the basis for my second objective. **Objective 2:** *To develop a theoretical framework that can support the re-conceptualization of emergent intentional action by children expressed as gesture.*

The C-i-A construct encompasses embodied, extended and enactive forms of intentionality where the *Action-Ready-Body* is placed centre stage. This intentionality of action emerges, i.e. is *brought forth*, during our interaction with ourselves, the social other and the other as artefact. Our actions unfold across microgenetic, ontogenetic and phylogenetic timescales. This is used to motivate and validate the development of the partial descriptive feature-based, non-reductionist, non-computational architecture of Cognition-in-Action (C-i-A). The framework explicitly builds on examining what motivates our intercorporeal meaning-making and is presented in Chapter 3.

9.1.2 For Whom? Recapping the stakeholders

From Disorder through Capability to Capacity Accessibility to Stakeholders

My earlier collaborative research brought together a network of people. We engage directly with young people with (SSMI-CP), their parents, carers, teachers, therapists, clinicians and researcher/practitioners. This alliance, although diverse, supported the belief that young people with cerebral palsy do have capabilities to interact with themselves, the social other and the other as artefact. My research is carried out within the context of *Design for All* paradigms. My findings illustrate not only the value of re-thinking gesture for young people with SSMI-CP but also provide accessible protocols for interaction and tools to evidence capability and develop capacity.

Cerebral Palsy: Lived Experience as a Complex Dynamic System

As previously stated, the incidence of CP in Europe per 1000 live births ranges from 2-3. Cerebral Palsy is a non-progressive neurodevelopmental disorder which begins early in life and that occurred in the developing foetal or infant brain. People with CP may also have disturbances of: sensation, perception, cognition, communication and behaviour. A permanent disorder, it affects the development of movement and posture, often causing activity and participation limitations. These postural difficulties and changes in muscle tone can affect either upper and/or lower limbs. Later, these issues may contribute to compromised functional use of extremities limiting their lived experiences, activities of daily living and including interactions with physical artefacts. Thus, impact on quality of life for children and young people can be significant.

Originally identified and formally described as a neurological disorder of movement in the 1860s, despite its prevalence, there is still some research deficiency in empirical data with regard to the cognitive skills and pedagogic performance of children with CP. This is particularly evident in the age range of the young people who contributed gesture exemplars to the Child Gesture Corpus.

The relationships and dynamics, including the care of children and young people with cerebral palsy, are complex and involve many people. Interventions can clearly affect lifelong outcomes and the trajectory of development of children and young people with CP. Several findings in a recent review of the complex aetiology of cerebral palsy concluded that despite a decline in prevalence of CP, the minimum age of reliable diagnosis is controversial. Importantly and again timely for the research presented in my thesis, is that evidence remains

sparse for intervention outcomes for motor improvements. It is this context that informed the design of my interaction protocols.

The focus of my research at the theoretical and practical level was to rethink not only the nature of intentionality, but also how tools could be developed to capture and analyse such complex interactions. The working assumption was that such tools could then offer opportunities for more informed interactions that could impact on quality of lived experience for people with CP. The need for early intervention is well established, as is the need for interventions based on more rigorous scientific evidence for efficacy.

The historic construction of disability, rehabilitation and changes in practice falls outside the main scope of this thesis. However, as transdisciplinary researchers/practitioners we perhaps should consider rethinking not only gesture-as-performance but also the nature of *professional alignment* within such complex systems. Read in this context, we could become more allied to the community within which we operate. I would suggest that such re-alignment supports the ethos of the work of this thesis. A re-focusing on factors that support embodied, embedded, extended and enactive intentionality offers us the opportunity to reconsider how to enrich human potential and capacity through corporeal expression.

I would go on to argue that all our children and young people should have access to opportunities for expressive engagement whether within education, therapy, the medical sector or the arts. Importantly, this should be irrespective of established perceptions of their capabilities.

9.1.3 The How?

The Child Gesture Corpus

One of the outcomes of my earlier collaborative research was the establishment of The Child Gesture Corpus (CGC) video collection which has a significant number of exemplars of intentional gesture from children and young people with SSMI-CP. The original exemplars were collected for research into the computer recognition of dynamic arm gestures. The corpus was later added to with gestures from neuro-typical children; this work is not presented in this thesis. One of the initial tasks for this early research was essentially a question of: *How could interactions be crafted to engage and explore the potential of intentional physicality and tangibility?*

My thesis research began by revisiting an underlying premise that children with SSMI-CP could potentially access or even control more of their intentionality. After re-examining the earlier ethnographic study; talking with clinicians, teachers, therapist,

accessing verbal testimony and written records and working with young people with SSMI-CP, further questions began to suggest themselves: *How were young people and children with severe speech and motor impairment engaging their imaginations? How were these young people expressing themselves corporeally through gesture? How were they interacting with the social other and the other as artefact?* These questions influenced the formulation of **Objective 3:** *To outline an inclusive methodology that has the capacity to investigate neuro-atypical and neuro-typical gesture within the same paradigm.*

Revisiting - The Child Gesture Corpus

The corpus clearly holds evidence of emergent enriched, embodied, self-initiated corporeal intentionality. The theoretical and methodological challenge in my research was to investigate how to re-examine these exemplars and address some of the *How* questions. Key to the contributions made to the corpus was the enhanced participation of children with CP.

Three case studies provided exemplars of corporeal intentionality as young people engage in ludic interactions. Chapter 4 outlined the methodology that facilitated these young people's contributions to the Child Gesture Corpus. This underpins the selection and data analyses of the exemplars presented in the empirical study.

In this context, mention should be made of the role of the *social other* when it is embedded as technology. Specifically, at the time the Child Gesture Corpus was established the co-participants' AAC devices were excluded by mutual agreement. This allowed opportunities for the exploration of more direct inter-corporeal interaction. These communicator machines often mask the corporeal expressivity of their users. It should however be noted that the difficulty of achieving inter-subjectivity and corporeal attunement when using AAC devices has only recently been highlighted in the literature. Such literature and findings further highlight my new contributions to knowledge in the area of corporeal expressivity of people with Cerebral Palsy.

Ludic Interaction – Performance: In the Moment and Over time

Practices from both the pedagogic and participatory performance art arenas informed and influenced the development of the protocols. The focus of these interaction protocols was on the need to maximise both engagement and corporeal participation. I revisited the nature of intentionality in the context of ludic interactions both with the social other and the other as artefact. The resulting protocols can be used to enhance existing interaction of children and young people with SSMI-CP experience with their parental/carer, clinical/therapeutic, and

performing arts practitioners. Ludic interactions can be tailored to an individual's initial capabilities. Importantly, the nature of the ludic designs allows for dynamic changes in interaction both within the moment and over time. This allows for the development of protocols to extend capability and enhance capacity.

The protocols allow for the narrative nature of interactions to be integrated. This facilitated the introduction of the social other as 'characters' and the introduction of personalised artefacts that can greatly enhance engagement, e.g. favourite toy, puppets, props, digital technologies and every day and/or abstract objects/textures and materials.

These 'social others' can be:

- *Veridical, e.g. carer, parent, friend, therapist;*
- *Imaginary; driven by the child or*
- *Alluded to by the context or narrative nature of the protocol or*
- *Virtual with the aid of augmented technologies and/or*
- *Hybrid i.e. a combination*

The ludic protocols for engagement are presented in Chapter 3 onwards. They are both ecologically valid and psychometrically sound. Importantly, they are designed to support the exploration of corporeal interactivity at various levels.

G-ABAS and G-IPA Annotation, Interpretation and Analyses

Research gaps were identified in terms of formative assessment of movement and communication and corporeal expression, both at an empirical level for gesture studies and medically. These were discussed in Chapter 2 and justified the development of two tools. This work informed **Objective 4: *To identify, develop and adapt qualitative tools to support the annotation and interpretation of bodily expressed child gesture.*** The tools developed were firstly, an extensive body-based action annotation system for the fine-grained analyses of interactive movements captured on video (G-ABAS), and secondly, an Interpretative Phenomenological Analysis method adapted and used for gesture (G-IPA) for the first time. This underpins the selection and data analyses of the exemplars presented in the empirical study. Three case studies provided exemplars of corporeal intentionality as young people engage in ludic interactions. Chapter 4 outlined the methodology that facilitated these young people's contributions to the Child Gesture Corpus. These tools were described in Chapter 5, together with their advantages and limitations.

Key aspects of the C-i-A conceptual framework were instantiated through the analyses and interpretation of exemplar gestures from the three cases studies. This work informed **Objective 5: *To examine what gestures reveal about children's corporeal***

Cognition-in-Action. In Chapter 6, I presented the first level of interpretative analysis that examined both corporeal dynamics and corporeal narrative features. The feature-based analyses reveal details about the nature of the imaginary precepts and veridical artefacts that these young people brought forth during their ludic interactions. These enactions unfolded in a gesture sphere that encompasses peripersonal, allocentric and far space. This level of analysis begins to examine performance strategies within this gesture sphere.

9.2 Meaning and Practical Implications

9.2.1 What is offered to stakeholders?

In essence, in my thesis I argue and provide evidence for re-focus on both models and practices that place the *Action-Ready-Body* centre stage. Rethinking gesture in terms of intentionality and corporeal expressivity provides opportunities for stakeholders to understand capability and begin to develop capacity in young people with Cerebral Palsy. Video documentation is coupled with fine-grained annotation and analysis and is informed by the C-i-A framework. The psychometric potential of the tools developed in my research has been discussed Chapters 6-8. In summary, the outcomes of my thesis offer three things to stakeholders:

- *A theoretical framework to enhance our understanding of the nature of corporeal intentionality for children with severe speech and motor impairment (SSMI-CP)*
- *Ecologically valid inclusive interaction protocols that can be used to engage, and encourage active participation through physical expressivity and*
- *Observational annotation and analysis tools that can be used to document capability and develop capacity illustrating the progression of intentionality*

Evidence from my findings illustrates how we can begin to gain a deeper understanding of the complex nature of cerebral palsy child gesture as it unfolds, is brought forth and carries forward within a dynamic system. Outcomes from **Objective 6: To consider the relationship of the underlying enactions subsystem** and **Objective 7: To identify the practical utility of the gesture based annotation and interpretative phenomenological analysis tools within the Cognition-in-Action conceptual framework**, supported the development and validation of the conceptual framework and tools.

In Chapter 7 I presented the second and third level of interpretative analyses with an examination of aspects of the complexity that underlies the enactions of gestures by cerebral palsy children. The interpretative findings were discussed in terms of two enaction sub-systems: those of *gestural flow* and *conceptual integration*. Prototype templates for use by practitioners can be found in the appendices. At the end of this chapter I provided a

hypothetical future use case scenario that illustrates both the meaning and practical implications for practitioners, parents/carers and potentially young people themselves.

9.2.2 Utility & Timeliness of the C-i-A framework and GABAS tools

The merit of the C-i-A framework, GABAS and G-IPA tools is that they are theoretically consistent as well as being timely. They can be used with or without technology infrastructure and with minimal training. They also have the potential to be ported into almost any existing multi-modal annotation software systems. This would require the porting of numerous specific fields. The advantage of such work would be that these technology-dependent systems could then become more inclusive.

Significantly, my theoretical framework and tools can be used in isolation or as an adjunct to existing assessments and practices. For example, they can be used in conjunction with the WHO model of disability and the International Classification of Functioning, Disability and Health (ICF) framework. In terms of assessment they could enhance the use of, e.g. imaginary and play assessment as well as movement science and therapeutic psychometric instruments such as the Paediatric Evaluation of Disability Inventory (PEDI); GAS goals.

The timeliness of my work, particularly the ludic game protocols, is seen in its potential to be combined with technologies that have the capacity to capture enactive actions and interactions. This is exemplified in part by recent work on paediatric rehabilitation, pedagogic learning, edutainment and leisure gaming, alternative therapies and performance art.

In Chapter 8 I discussed the research findings and the practical utility of the G-ABAS and G-IPA tools within the context the C-i-A framework. Evidence for three claims is provided:

- *Firstly, that gesture is a subsystem of our biosemiotic interaction*
- *Secondly, that gesture is pivotal for our sense-making activities; and*
- *Thirdly, that gesture is critical for our corporeal and social evolution.*

The C-i-A architecture is revisited in the context of the work of others and its utility as a conceptual framework; specifically, as it contributes to a better understanding of intentionality in terms of complexity, connectivity and temporality of young people's corporeal action.

9.3 Future Work - Next steps

9.3.1 Movement Science, Gesture Studies and Performance

In the last two decades concepts from dynamic systems theory of motor learning, control and embodiment have been revisited by researchers. Those who recently examined the issue of the impact of knowledge on practice found that for therapists, although *'a change in their clinical practice has occurred in the last year, gaps still exist and the shift has not been fully incorporated'*. However, therapeutic practices still predominately focus on abilities to complete largely functional tasks (activities, i.e. personal) and participation (i.e. socially) in everyday ecological settings. These researchers argue that such clinically based approaches still direct the majority of effort towards *'changing aspects of the child, although evidence for benefit is limited'*. Importantly, they also found that: *'impairment-level approaches are not grounded in evidence and it is uncertain whether such efforts will translate into improved functional independence.'* I would argue that from a practitioner perspective the key question to keep in mind is: *Can interaction relationships and ecological conditions be influenced in a way that can firstly reveal gestural capability in children and secondly develop their capacities?*

In the UK, the latest NICE guidelines on CP speak to the need and challenges for early intervention and portage (intervention in the home) for young people with cerebral palsy. Researchers have highlighted both the feasibility and effectiveness of home-based interventions and proposed protocols for systematic reviews. They argue for the focus to be on interaction between the environment and the people rather than on body function per se. They suggest that *'further qualifiers focussing explicitly on attending and degree of involvement'* within *'an overarching environmental framework'* are needed.

More broadly, and with a transdisciplinary framework such as that found in my thesis, the NICE guidelines also endorse the need for early multi-disciplinary approaches. They argue that this approach should apply, not only for diagnosis and care, but also intervention and pedagogy.

9.3.2 From Systems Thinking to Transdisciplinary Systems Practice

My thesis presents a *Biological System Theory* approach that is framed within the still emerging enactivist paradigm of cognitive neuroscience where dynamic aspects of interaction are pivotal. Although we are still developing the theoretical foundations of this paradigm, it was chosen as the best candidate to support the development of the Cognition-in-Action theoretical framework. In this section I reflect on how the predictive power of the C-i-A framework and the tools can be increased in the context of future research and practice. In

terms of accessibility they have been designed using participatory design practice within a *Design for All* paradigm. This facilitates their use with people who have diverse neurology and across age ranges and transdisciplinary boundaries.

Movement science

Systems-level views of motor control are beginning to re-emerge. Although many still remain brain-bound from a neurological perspective, authors agree: *‘that viewing the cerebellum, basal ganglia, and cortex as an integrated system enables us to understand the function of these areas in radically different ways’*. In addition, they suggest that: *‘future experimental and computational work is needed to understand the function of cerebellar-basal ganglia circuitry in both motor and non-motor functions.’*

In terms of the implications for practice these perspectives highlight two main points; firstly, that: *‘the integrative dynamics of the cerebello-basal ganglia-thalamo-cortical system is a vibrant and relatively new theme’* and secondly, that: *‘further research will likely require new network-based monitoring/therapeutic methods and systems-level computational models’*.

Such views place my work within this timely context and support the theoretical framework proposed in my thesis for understanding physically expressed intentional corporeality. In terms of the further quantitative analysis of human movement for the detection of CP, several authors propose the use of movement capture data analyses by applying various methodologies. An earlier attempt was made to consider the C-i-A framework in terms of dynamical system theory and to apply formal mathematical treatment to the concept of neuro-atypical movement.

This is in line with work that argues for a refocusing on the importance of variability in serving exploration and the potential to sculpt the nervous system. I have argued that it would not only be the nervous system in isolation that can be sculpted, but also the body as a whole. Although this is an area for future development of the C-i-A, such work can also be read to support my arguments for both early interventions and the development of evidence-based tools.

Gesture Studies

From the Conventional to Gesture and Language

The corporeal gestural phenomena that I examine clearly go beyond the brain. The repertoires of children and young people, who contributed to the Child Gesture Corpus are clearly social and unfold both for the individual and groups across microgenetic time scales. They are also reliant on and linked to ontogenetic and phylogenetic timeframes.

My thesis is timely, since the conventional conceptualisations of language to which gesture has previously been historically bound, are also being re-thought. Linguists are being urged to take a broader multi-modal approach to language. They are bringing into question the appropriateness of the spoken language analytical model being applied to manual languages. Furthermore, there is a call to include semiotic diversity, i.e. a consideration of *language as an abstract system and Linguaging*, within *distributed ecological activity* where *wording* is a part. The importance of the spatio-temporal dynamics of systemic thinking is being described as *cognition emerging in ecological space-time*. Clearly, such situated activity involves not only our brains, but our motor actions and artefacts. Interestingly, a recent special issue review highlighted a shift from ‘*action for language to language for action*’ where it was proposed that: ‘*embodied breakdown of language deficits should be seen as novel avenues into movement disorder*’.

Performance & Practice Alternatives

In my work I looked towards situated, embodied and enacted practices, particularly in participatory performing arts and the alternative therapies sector that focus on developing what I term ‘*corporeal repertoires*’. There are examples of transdisciplinary approaches within the disciplines of embodied performance that are being applied in research that brings together performance art, pedagogy and practice. Such transdisciplinary approaches are illustrative of work theoretical grounded and embodied in practitioner methodologies. These included ethnographic methodologies of theatre, dance, music and film. Such examples illustrate how the participatory art can cross clinical boundaries.

The tool development and analyses with case studies were presented in Chapters 5-7. This aspect of my work illustrates the value of looking at the variation in the movement repertoires of heterogeneous populations. Individual profiles of motor cognition, i.e. Cognition-in-Action, which is embedded ecologically, can be read in conjunction with neuropathology and used to inform both existing and novel interventions to improve cognitive and motor outcomes. Aspects of C-i-A model interaction protocols, together with the annotation and analysis tools, could provide alternatives and/or provide adjuncts to traditional interventions to make them accessible to young people with higher levels (levels IV-V) of physical involvement. These could include, for example conventional therapeutic interventions and the growing number of VR, AVG and exercise interventions.

However, the allied health and participatory arts work areas are providing examples of practice that explore active participation through e.g. music, dance, film and theatre and more recently social circus. Extending the idea of the others within the C-i-A framework,

either as co-performers, virtual therapists or ‘the social other’, consideration was also given to research where the social is embedded in technology. Recent advances in wearable and tangible artefacts is illustrative of how both the intentionality premise and artefact concept within the C-i-A model could be used to support the active and corporeal physical participation of children with SSMI-CP. Such participatory performance arts work could provide not only alternatives but also extension to conventional face-to-face therapy and health sessions.

Deconstructing conventional medicalization of disability

It has also been proposed by authors from the critical disability studies field that there is a need to deconstruct conventional medicalization of disability. They have suggested that social-cultural conceptions of disablism not only place social impositions on and restricted activity of people with impairment; but also endanger and undermine their psycho-emotional well-being.

My research proposes a re-thinking of gesture within the sociological reconsideration of disAbility where intentionality of gesture-as-performance enables us to look not only at capability but also capacity. This places gesture within an embodied cultural matrix allowing us to move away from normative standards and perceptions of cerebral palsy movement repertoires and towards an exploration of the potential for creative expressivity. I would suggest that such realignment supports the ethos of the work of this thesis. My biological systems approach not only brings together theoretical domains but also supports an approach where each stakeholder is valued through their interaction of joint experience, genuine participation and engagement. It also highlights the shifts in thinking towards more ecologically valid work that considers the complexity of participation.

The outcomes of my research offer us the opportunity to reconsider how human potential and capacity can be enriched through corporeal expression. Furthermore, I would go on to argue that all our children and young people should have access to opportunities for expressive engagement whether within education, therapy, the medical sector or the arts. Importantly, this should be irrespective of established perceptions of their capabilities.

The dissemination of the outcomes of my thesis will include research publications and the translation of knowledge through direct access, including stakeholder networks and web-based media. In terms of stakeholders, including young people with CP, parents/carers and clinicians and allied professionals, this will be done at no cost and will require minimal training. In the first instance, work with stakeholders will examine the interaction protocol

and the annotation/interpretative analyses for use with the *Spatial Kinaesthetic Interaction Profile* (SKIP) profiles in terms of accessibility, format and platforms.

9.3.3 Summary and Hypothetical, Future Use-Case Scenario

My work is placed alongside that of others that argue for the importance of enabling people with cerebral palsy to actively participate in their lives and not only their care. My critical literature review (Objective 1); lends support to both the phenomenological and transdisciplinary approach of my work. It supports not only the interdisciplinary, but also my Biological Systems Theory approach. The findings of my review informed the development of the C-i-A framework (Objectives 1 and 2); presented in Chapters 1-3; and the ludic protocols (Objective 3); presented in Chapter 4. The theoretical C-i-A framework supports the development of the associated whole body annotation scheme G-ABAS and the Interpretative Phenomenological Analysis methods (G-IPA) (Objective 4); presented in Chapter 5. My research is timely and contributes new knowledge for a deeper understanding of corporeal expression in the domains of movement science, gesture studies and allied and participatory arts and health practices (Objectives 5-7), presented in Chapters 6-8.

Importantly, the timeliness of my theoretical C-i-A framework and tools allows for analyses of extensive corporeal expressive repertoire features from neuro-diverse people. My framework and tools have the potential to be used to both document and develop the profiles of children and young people with physical/cognitive challenges. Their predictive power can be increased when coupled with advances in both data sensor fusion approaches and developments in interactive software. My theoretical discussion and analyses provide a deeper understanding of corporeal gesture. My work is an example where both evidence-based data and a nuanced understanding carry with it implications for the research stakeholders, particularly in terms of informing future interventions and supporting better cognitive, movement and social outcomes for people with SSMI-CP. My overarching aim was to reconsider the nature of the physical, emotional and intellectual interaction for children and young people with Cerebral Palsy, with a view to empowering their intentionality. I end this chapter with a hypothetical, future use-case scenario to illustrate the potential use and implications of my work. The scenario is grounded in the C-i-A framework supported by the tools. Importantly, the emphasis is on documenting and empowering the development of corporeal expression by placing the *Action-Ready-Body* placed centre stage.

The SKIP Studio - A Hypothetical Future Use-Case Scenario

Adelphia is a young person with quadriplegic cerebral palsy, aged 7. She has severe dysarthric speech and is a wheelchair user. She enjoys listening to her favourite stories and music on her iPad. Adelphia has no apparent significant gesture repertoire; she has limited control over her eye gaze and uses consistent blinking for yes/no responses. Adelphia is able to make gross movement selections using her paper based communication aid located on her wheelchair lap tray. Only parts of her speech are understood by a familiar communicator, i.e. on conventional scales she is classified as SSMI-CP; GMFCS level V and MAC level IV. Cognitive assessments to date have been inconsistent. Pedagogically she is operating at P levels. She has recently been introduced to a simple electronic AAC device which she is attempting to access via a head switch. Adelphia needs assistance for all her ADL. She lives at home with parents, younger brother and an older sister; she has a favourite cuddly bear. Adelpha attends her local special needs school.

Her familiar communicators know that she can understand familiar story sequences and has good attention when motivated to engage. Parents, teachers and therapists have reported that they have seen a slight change in Adelphia's level of attention and they think she may be able to explore a physical, corporeal expression programme.

She has joined us in the creative studio to experience her first SKIP session and to work in collaboration with her parents, teacher, therapist, clinician and a participatory art practitioner. The SKIP studio includes: digital motion capture technology, a non-encumbered VR cave, social circus harnesses and exoskeletons, hard and soft robotic toys and a variety of ordinary and smart textural artefacts. Software is able with data fusion techniques to assist with the analysis of corporeally expressed intentional movements; including atypical movements. Adelphia has been seen to produce both gross (often with a chaotic dynamic profile) movements and micro-movements.

Adelphia works collaboratively, supported by the team. She is observed listening to her favourite stories, music and playing with her cuddly bear within the studio environment. Today the studio has been configured to look and feel like her classroom. Her gesture repertoires are captured on video.

Over several sessions her favourite stories are used to develop an engaging narrative sequence with novelty elements. The sequences are embedded in ludic games based on Adelphia's real world experiences and giving opportunities for her to engage her imagination. A set of potential gestural movements are selected for Adelphia to explore. They include opportunities for Adelphia to attempt to modulate any movements that emerge.

The gesture repertoire which unfolded in 3D space and time has been digitally captured. It is discussed and annotated using G-ABAS. The annotators are looking for evidence of intentional action which will have corporeal dynamic and may have narrative features. These repertoires are interpreted using the G-IPA levels and the C-i-A framework as a guide. This work is iterative and cyclic as the evidence informs the next generation of interactive ludic games. This data is combined with 'video and photo moments' captured by Adelpia's parents, family, teachers and therapists.

Over time and reflecting on any additional data sources, a Spatial Kinaesthetic Interaction Profile (SKIP) is compiled that established Adelpia's initial capabilities and documents the progression of Adelpia's corporeal expressivity. The profile also includes motor-cognitive and metacognitive features which may include: Engagement: Attention, Situational processing (including-planning, problem solving and anticipation) and Purposeful response. A C-i-A creative expression score including features of gestural flow and conceptual integration, and a C-i-A functional score, are generated.

An online platform allows for contributions and sharing of media and reflective comments from all the stakeholders. Interactive software supports the documentation of Adelpia's skills, progression and assessments. This mapping matrix can be manipulated using a visual interface, in both screen based 2D and 3D using a projection app.

The profile informs the future sculpting of Adelpia's pedagogic and therapeutic interventions. Integral to the SKIP is the design of an individual and later group creative participatory arts programme. Future sessions will explore how Adelpia can be enabled to physically act out her favourite story characters and trigger narrative events via synthetic characters and embedded artefacts. These artefacts may be veridical and/or virtual. Her direct control of the virtual or hybrid environment will increase as she is motivated to build a consistent gestural repertoire.

Personalized technology enables an individualised SKIP to be implemented. It is envisaged that as Adelpia's corporeal expressivity develops her next generation personal technologies likely to include a fully integrated communicator, linked to wearable and tangible components with embedded AI including enabled sensors. The portability, ubiquitous connectivity of the system enables effortless transition for use at home and school, in therapies and in the wider community. When Adelpia first meets her cuddly bear's new friend she is delighted and empowered to find that her micro-gesture can make it speak and her gross movements make it move!

"Expression is like a step taken in the fog--no one can say where, if anywhere, it will lead."

p.3 SNS (1964) Maurice Merleau-Ponty

Appendix Chapter 1

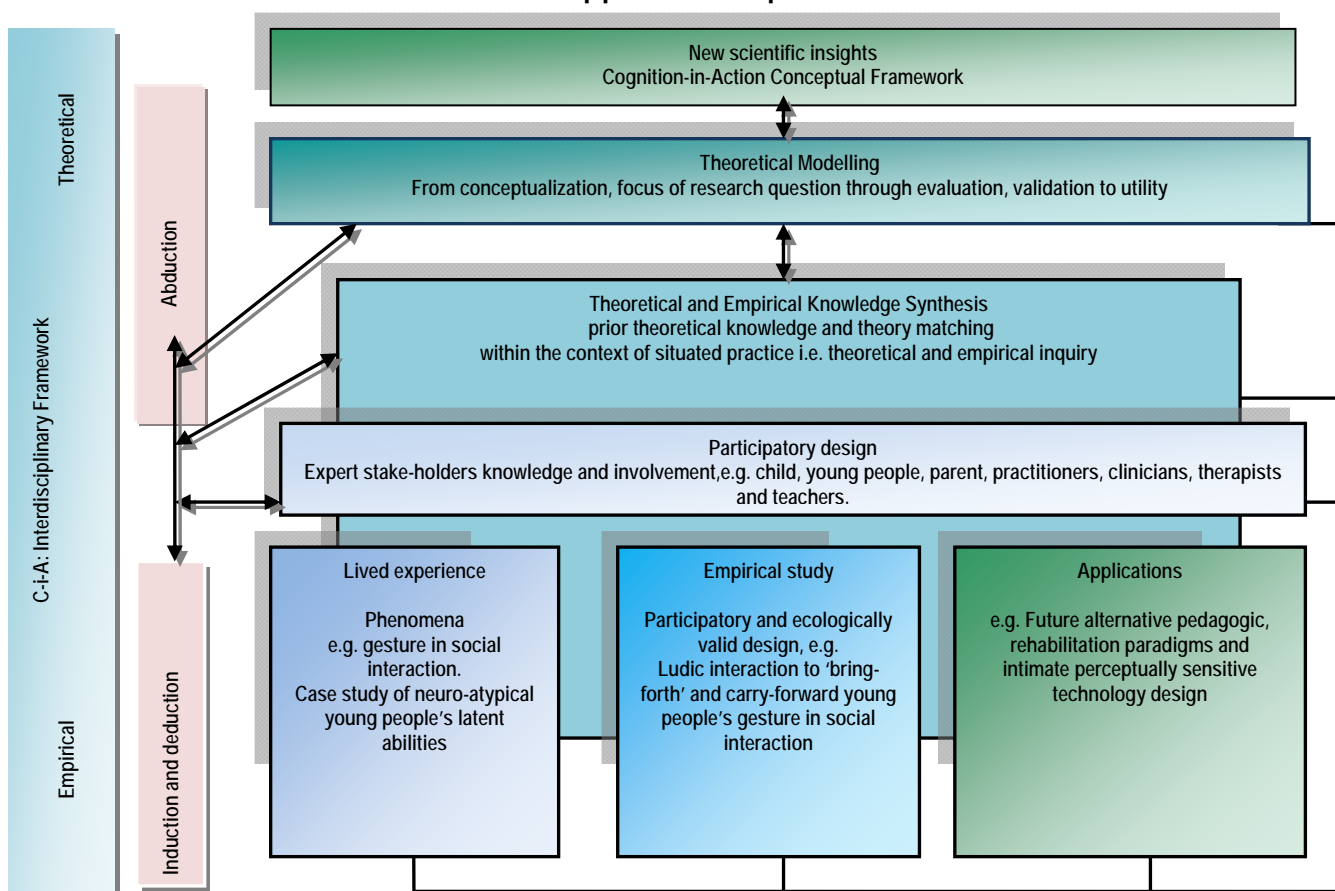


Figure A.1.1 A simplified schematic of the elements of abductive, inductive and deductive research process applied to the development of the interdisciplinary aspects of the C-i-A framework; see also Soft methodologies Dick (2002) and Reinberger (2008) for system biology innovations.

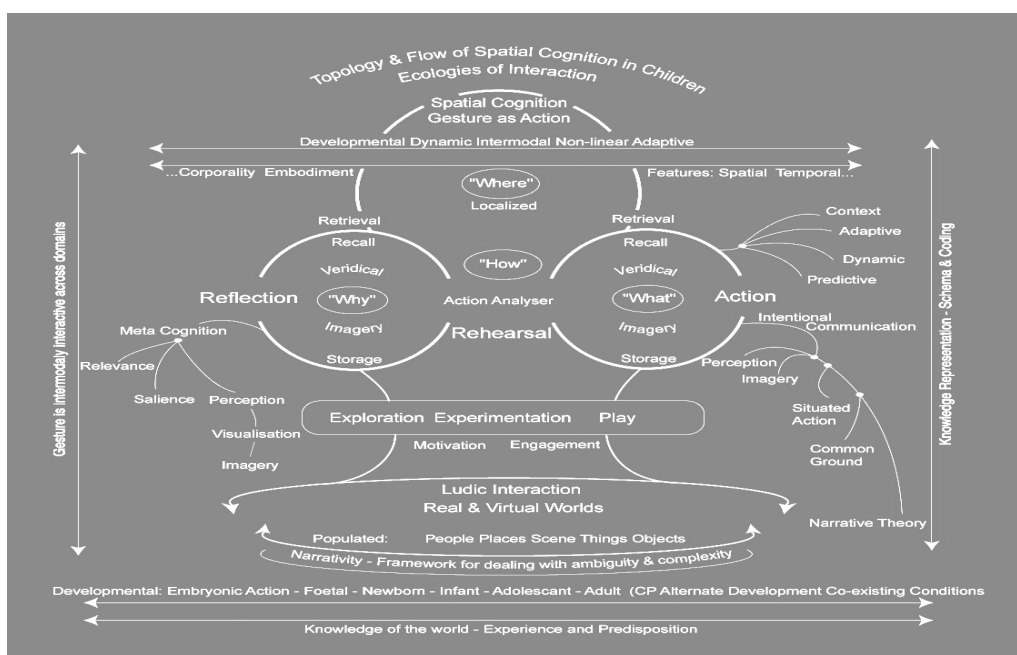


Figure A.1.2 Spatial Cognition in Children Topology and Flow of Ecologies of Interaction, Panayi and Roy (2005) A simplified schematic.

Appendix Chapter 2

Selected Authors	Neural correlates/area	Aspects of movement
Tolman (1949/1992) Pascual-Leone et al (1994) Ghaem et al. (1997) Passingham (1996); Jueptner et al. (1997) Thompson-Schill et al (1997)	Cortical regions 'Place cells' hippocampus Frontal cortex Prefrontal cortex	Physical location and spatial decisions Implicit and explicit knowledge 'navigation of memorized routes' Attention to action Retrieval of semantic knowledge
Kakavand et al. (1997), Rizzolatti et al. (1988/2004) Iacoboni et al. (2006) Gallese (2003a,b) and Gallese et al. (1996, 2005,2009) Lamm et al. (2001) Poldrack et al. (2005)	Premotor Mirror Neuron system (MNS) (AIP) F5 neurons Motor regions	Preparation of sequential movement, including 3D volitional movement Executed and observed action Pragmatic representation Dynamic visuospatial imagery Motor skill automaticity
Thaler et al. (1995) (voluntary) Lotze et al. (1999,2006) (imagined) Lau et al. (2004b) (representation)	Supplementary(SMA) and (pre-SMA) pre supplementary motor	Intention and anticipation or voluntary and imagined and representation of action
Fogassi et al.(2007) Pandya and Seltzer (1982) Deco and Rolls (2004) Binkofski (2000) Aron et al. (2004) Brass and Haggard (2007); Brass et al (2007)	MNS Prefrontal cortex (PFC) (ventral and dorsal) BA44 BA9 dFMC, PreSMA,CMA and BA9	Imagery of motion, possible role in visuo-motor transformations Peri-personal space Object recognition Response inhibition Self-control/Inferential system
Schiller et al. (2009) Decety et al. (2006/8/9) Vogt et al.(2003) (motor function) Dreyfus (2004)	Posterior cingulate cortex and amygdala Insula	Social Information (first impressions). Imagining action of self and other 'Cognitive control, task coordination and working memory', adult skill acquisition
Hanakawa et al. (2003)	Area 5	Somatosensory motor integration. Analysis of proprioceptive information - body part location
Decety et al. (1994) Grafton et al. (1996/1998) Pulverman et al. (2008) Pulvermüller et al. (2005)	BA7 (superior) and BA 40 (inferior) Posterior parietal regions Linking motor and language regions	Activation of hand movements Attention to manner and path, non-linguistic dynamic events
MacSweeney et al. (2004) Emmorey (2005)	Posterior Temporal Gyrus PTG	Manual language processing , BSL, ASL including tool use, modality independent
Nair et al. (2003) Özyürek et al. (2007) Holle et al. (2007) Willems et al. (2006),Gentilucci (2006), Xu et al. (2009)	Superior parietal lobule STS, inferior parietal lobule and percentral sulcus Broca's area	Attention and memory Iconic and semantic processing Possible interplay of language and gesture
Fletcher et al.(1995) Ogido et al. (2000) Ruby and Decety (2001)	Superior parietal lobule STS, inferior parietal lobule and percentral sulcus Broca's area	Attention and memory Iconic and semantic processing Possible interplay language and gesture
Desimone and Gross (1979) Binder et al. (2009), Grossman et al. (2008) Hubbard et al. (2008) Calvert (2000) Campbell et al. (2011) Pekkola et al. (2006) Kraemer et al. (2005) Fogassi et al. (1992)	STG/S Polysensory area monkeys STSp posterior temporal sulcus STC – Superior temporal cortices- left ST gyrus/sulcus Various including Planum Temporale PT Superior Temporal Gyrus Inferior temporal cortices	Integration of auditory and visual speech. Semantic memory review of fMRI Representation of biological motion Point light display recognition 'Musical/rhythmic information/ imagery Action, object recognition
Naito et al. (2002) Pazzaglia et al (2008) Chao and Martin (2000) Rumiati et al (2004)	Cerebellum Dorsal Stream Distributed regions	Internally simulated movement, motor imagery Gesture recognition, patients with limb apraxia Representation of man-made objects Pantomiming use of visual objects

Table A2.1. This table summarizes illustrative references that informed the development of a derived '*neurology of gesture*' and neuro-dynamic aspects of the C-i-A framework. It shows the brain areas involved in motor action, imagery and aspects of spatial cognition. Research on humans and primates or other species have not been differentiated, extract, after Panayi (2010).

Conventional Models		Alternative Models/Frameworks e.g. C-i-A framework and G-ABAS and G-IPA tools	
Child Gesture Notation Scheme	Theoretical Models	Child Gesture Notation Scheme	Theoretical Model (SCA)
Gesture form and topology <i>Linguistic</i>	<p>Linguistic and increasingly socio-linguistically influenced theoretical models.</p> <p>Typical applications beyond research include the prediction of early language/vocabulary development, mechanism for language learning; readiness to learn and more recently to spatial learning. In neuro-typical children as part of intervention programmes to improve communication.</p>	Gesture form and topology <i>Biological</i>	<p>Dynamic non-linear complex system that involves intersubjective, intercorporeal participatory-sense-making system.</p> <p>Potential applications in the design of future creative therapies, enchantment of quality of life through opportunities for creative expression, creative therapies, activity based clinical therapies and diagnosis and the development of future perceptually sensitive technologies including multi-modal augmented and alternative communication systems</p>
<i>Notation Parameters</i> Typical 5 types e.g. 5 movement/configurations		<i>G-ABAS</i> <i>Notation features</i> Two themes, 5 strands in each capacity to code for 260+ features	
<i>Deictic</i>		<p>Two themes: Corporeal Dynamics and Corporeal Narrative that relate to the self, the social other and the other as artefact that unfold within the corporeal sphere and the interaction environment (veridical, imaginary, hybrid)</p> <p>Corporeal Dynamics Motion Events <i>Abstraction of action</i> <i>Manipulation of action</i> <i>Object representation</i> <i>Interaction description</i> <i>Emotional Salience</i></p> <p>Corporeal Narrative</p> <p><i>Source of narrative knowledge</i> <i>Scale of narrative</i> <i>Narrative Gesture Space</i> <i>Manipulation of abstract thought</i> <i>Narrative Emotional Space</i></p>	
<i>Conventional</i>			
<i>Representational (iconic and metaphoric)</i>			
<i>Beat</i>			
<i>Emblem</i> , i.e. conventionalised gesture such as 'OK'			
Movement configuration in space			
<i>Hand-shape</i>			
Movement of hand			
Location of hand in space			
Path and Manner			
Six simple movements, e.g. spiral, straight line, curved line			
Narrative			
Point of view (POV) derived from associated parameters related to speech, e.g. deixis indicative of POV and features of plotlines and use of space.			

Table A2.2 An illustration of the relationship of the C-i-A framework and G-ABAS topology in relation to conventional notation schemes and related theoretical models, compiled from several authors; see main text for references to reviews of notation schemes.

Comparison of Communication Classification Systems Illustrative developed and normalized for neuro-typical young children 6 months and 2 years, extended to 6 years for NAT children		
System, developers, source, date	Example of relevant item	Format/use
Early Social Communication scales (ESCS) Seibert and Hogan (1981)	Vocalizations, gesture, words	(NT); (NAT - older) Can be used in structured interactions
Mullen scales of Early Learning (MSEL) Mullen. (1995)	e.g. differential sound production in babbling Presence of gesture/language games	(NT) Diagnostic
MacArthur-Bates Communication Development Inventory (MCDI), Fenson et al. (1994)	Words and gestures	(NT) : (NAT) Diagnostic Informants questionnaire e.g. parent, clinicians
Communication & Symbolic Behaviour Scales Developmental Profile (CSBS DP) Wetherby and Prizant (2003)	Eye-gaze, words, gesture, sounds, object use	(NT); (NAT) Diagnostic Informants questionnaire e.g. parent

Table A2.3 Illustrative comparison of communication classification systems normalised for neuro-typical children Key: (NT) Neuro-typical, (NAT) Neuro-atypical.

Comparison of Communication Classification Systems Illustrative developed for used with neuro-atypical young children		
System, developer, source and date	Example of relevant item	Format/use
Communication Matrix Rowland, C. (1990/2009), interactive online version www.communicationmatrix.org	Seven levels of communication: Preintentional, Intentional pre-symbolic and unconventional (e.g. tugging gesture), conventional (presymbolic), concrete symbols (pictures, iconic gestures, sounds of what is represented), abstract symbols (speech and manual signs i.e. not necessarily similar to representation), language (symbols that are concrete or abstract). Use together with four reasons to communicate and nine categories of behaviour	(NAT) Observation tool Research, being developed for potential clinical/pedagogic use Reflects current status, rather than a particular chronological age or other comparison group
Similar to CSBS and ESCS tailored to meet needs of older children with severe disabilities, Mclean et al. (1991); Brady et al. (2008) and Communication Complexity Scale (CCS) Brady et al. (2012)	Ordinal scale, 11 different levels (av. of three highest scale scores) Three categories: preintentional (perlocutionary), intentional (illocutionary) and symbolic (beginning locutionary) Include AAC – speech generating device (SGD), but manipulation not included as gestures	(NAT) Observation research tool, applied to scripted videotapes has potential use: clinically and by parents Reflects current status, rather than a particular chronological age or other comparison group
Inventory of Potential Communication Acts (IPCA) Sigafos et al. (2000)	53 questions, 10 pragmatic functions	(NAT) Interview schedule e.g. parent, therapist, clinicians
Gesture-Action- Based- Scheme (G-ABAS), Panayi et al. (2000); Panayi (2010); Panayi (in prep.)	Two phases: Corporeal Dynamic features and corporeal narrative features can be annotated for a range of intentional self-initiated movement. The latter can be used for more complex interactions. Such movements embedded in interactions e.g. imaginative and real world play interactions including manipulation of everyday objects and toys. Capacity for 260+ features	(NAT); (NT) Observation tool Research, applied to videotapes, being developed for potential clinical/pedagogic use. Can be used in conjunction with CFCS, GMFCS and Manual Ability Classification System (MACS) (see Table 3.5). Reflects current status and capacity, rather than a particular chronological age or other comparison group. Can also be used with neuro-typical children
Communication Function Classification System (CFCS) Everyday communication performance, Cooley Hidecker et al. (2010)	Five descriptive levels. CFCS Level 1, communicator is generally successful communicating with most partners and in most settings cf. Level V seldom effective sender and receiver with familiar partners. The other CFCS levels vary by how easily this shared understanding is established with familiar and unfamiliar communication partners. It included communication with both manual and electronic AAC	(NAT) Can be used in conjunction with GMFCS and MACS Manual Ability Classification System (MACS) (see Table 3.5)

Table A2.4 Comparison of Communication Classification Systems, illustration for used with neuro-typical and potentially neuro-atypical young children. Key: (NT) Neuro-typical, (NAT) Neuro-atypical.

Comparison of Communication Classification Systems Illustrative for use with gestures (typically normalized for neuro-typical young children 6 months -2 years and beyond)		
System, developers, source, date	Example of relevant item	Format/use
Mc Neill	Co-speech i.e. speech synchronised with gestures	Research/Observation and annotation tool Reflects current status Predominately structured interactions including: mother/infant studies; re-telling narratives;
Lopez & Sinha	Co-speech i.e. speech synchronised with gestures	Research/Observation and annotation tool Reflects current status, some studies have applied findings to prediction of 'readiness to learn', future vocabulary development Ethnographic/situated interactions studies including: mother/infant/child studies; native language; bilingual speakers; classroom learning
Gesture-Action- Based- Scheme (G-ABAS) Panayi et al, 2000; Panayi, 2010; Panayi (in prep.)	Corporeal dynamic features and corporeal narrative features can be annotated for a range of intentional self-initiated movement. The latter can be used for more complex interactions. Such movements embedded in interactions e.g. imaginative and real world play interactions including manipulation of everyday objects and toys.	(NAT); (NT) Research/ Observation and annotation tool also being developed for potential clinical/pedagogic use. Can be used in conjunction with CFCS, GMFCS and Manual Ability Classification System (MACS) (see Table 3.5). Reflects current status and capacity, rather than a particular chronological age or other comparison group. Can also be used with neuro-typical children

Table A.2.5 Illustrative comparison of communication classification systems normalised for neuro-typical children that focus on gesture, Key: (NT) Neuro-typical, (NAT) Neuro-atypical.

<p style="text-align: center;">Comparison of Cognitive Classification Systems Illustration for use with children with cerebral palsy (typically normalized for neuro-typical young children also used for children with widespread challenges)</p>		
System, developers, source, date	Example of relevant item	Format/use
<i>WPPSI, Wechsler Preschool and Primary Scale of Intelligence</i> Wechsler D. Manual for the Wechsler Preschool and Primary Scale of Intelligence– Revised. San Antonio, TX: The Psychological Corporation, (1967).	subscales of verbal or performance	Normed assessment tool Reflects current status
<i>Bayley scales of Infant Development BSID-II 1 month – 42 months of age, often used for evaluation children with widespread impairment</i> The Psychological Corporation (1993).	cognitive, motor and behaviour functioning	Normed assessment tool Reflects current status.
<i>Leiter International Performance Scale (Leiter-R)</i> Gale H. Roid, Miller, J.M. Stoelting Co. (1997)	for nonverbal function e.g. fluid reasoning, visuospatial memory, attention	Normed assessment tool Reflects current status
<i>Columbia Mental Maturity Scale (CMMS) (3 -9 years)</i> Burgemeister, B., Lucille H. Blum, L.H., Lorge.I. The Psychological Corporation	general reasoning that requires no verbal response and minimal motor response	Use with dyskinetic CP or quadriplegia Normed assessment tool Reflects current status
<i>Reynell Zinkin Developmental Scales</i> Reynell J, Zinkin PM. (1979) NFER	children with visual impairment and widespread disability who do not respond to other developmental scales	Normed assessment tool Reflects current status
<i>Test of Non-verbal Intelligence (TONI-2)</i> , Brown et al. (1990) Austin, TX: Pro-Ed	language free measure of abstract/figural problem solving abilities	Normed assessment tool Reflects current status
Gesture-Action- Based- Scheme (G-ABAS) Panayi et al, 2000; Panayi, 2010; Panayi, in prep.	Requires no verbal response Potentially performance measure linking cognitive-motor abilities Corporeal aspects of spatial cognition Nonverbal reasoning measure derived from corporeal response to dynamic auditory (speech); visual stimuli e.g. fluid reasoning (Gf) and crystallized intelligence (Gc) , visuo-spatial memory, attention	(NAT): (NT) Research/ Observation and annotation tool also being developed for potential clinical/pedagogic use as a measure of corporeal aspects of spatial cognition (see example of relevant items). Can be used to compliment traditional assessments. Reflects current status and capacity, rather than a particular chronological age or other comparison group. Can also be used with neuro-typical children

Table A.2.6 A comparison of Cognitive Classification Systems, illustrates their use with children with cerebral palsy (typically normalized for neuro-typical young children also used for children with widespread challenges). Developed after Sigurdardottir et al. (2008). Key: (NT) Neuro-typical, (NAT) Neuro-atypical.

Comparison of Movement classification systems Child movement including movement disabilities e.g. cerebral palsy		
System, developers, source, date	Example of relevant item	Format/use
Movement Assessment Battery for Children (Movement ABC-2), (3-16 years) Norm-ranked Henderson, E.S., David A. Sugden, A.D., Barnett, A. (1992/2007)	Eight items functional movement actions for Developmental co-ordination disorders. Provides quantitative and qualitative data child's performance within 3 subsections: Manual Dexterity, Ball Skills, and Static and Dynamic Balance	Diagnostic for (NT) and (NAT) Not suitable for children with severe motor disability i.e. wheelchair users
Gross Motor Function Classification System (GMFCS) Palisano,R., Rosenbaum,P., Walter,S., Russell,D., Wood,E., Galuppi,B. (1997) <i>Dev Med Child Neurol</i> 1997;39:214-223, revised and extended (2007) - for age 12-18years, compatible with World Health Organization's International Classification of Functioning, Disability and Health (ICF)	Focus is on function movement action i.e. not intentional gesture Based on <i>self-initiated movement, with emphasis on sitting, transfers, and mobility</i> in everyday living	(NAT) Primarily diagnostic in clinical settings suitable for children with cerebral palsy mild to severe (1-V) motor disability i.e. LEVEL I - Walks without Limitations LEVEL II - Walks with Limitations LEVEL III - Walks Using a Hand-Held Mobility Device LEVEL IV - Self-Mobility with Limitations; May Use Powered Mobility LEVEL V - Transported in a Manual Wheelchair. Emphasis on usual performance of gross motor function, rather than capability.
Peabody Developmental Fine Motor Scales (PDMS-FM) Folio & Fewell, (1983) Birth-seven yrs.	Grasp, hand-eye co-ordination, and hand use, manual dexterity	Muscle tone and range of movement (ROM) of the hand. Lack qualitative descriptions. Limited use for NAT
Quality of Upper Extremity Skills Test (QUEST) Dematteo et al, 1992 (18 months- 8 years)	Four domains: dissociated movement, grasp, protective extension, weight bearing	
Manual Ability Classification System (MACS) Eliasson, A.C. et al, (2006) <i>Dev Med Child Neur</i> 48:549-554 www.macs.nu Developed for 4-18 years	Focuses on cerebral palsy children's use of hand when handling objects in daily living i.e. performance not capacity Five levels	(NAT) Primarily diagnostic for communication with families, staff, goal setting, research Interpretation of levels needs to relate to age of the child Does not consider underlying components of complex hand movements
Gesture-Action- Based- Scheme (G-ABAS) Panayi et al, 2000; Panayi, 2010; Panayi in prep.)	Focuses on <i>capacity for performance</i> Corporeal Dynamic features can be annotated for a range of <i>intentional self-initiated movement</i> . The emphasis is on encouraging <i>I Movements embedded in enactions</i> e.g. pretend to: <i>hammer; lasso the steer; sip soda; do the ironing; play the violin; show an explosion</i> . Includes 'micro-gestures' e.g. <i>spider; caterpillar; snowflake; rain</i> <i>II Manipulations with real objects</i>	(NT) & (NAT) Descriptive gloss for annotation of video or still photographic evidence (with optional coding for expert users of coding scheme) suitable for use with children with cerebral palsy mild to severe (Levels 1-V, see GMFCS) motor disability Potential to be used for research or within interdisciplinary clinical, pedagogic settings. Does consider underlying components of complex movements

Table A.2.7 Comparison of movement classification systems for children, including NAT children with CP

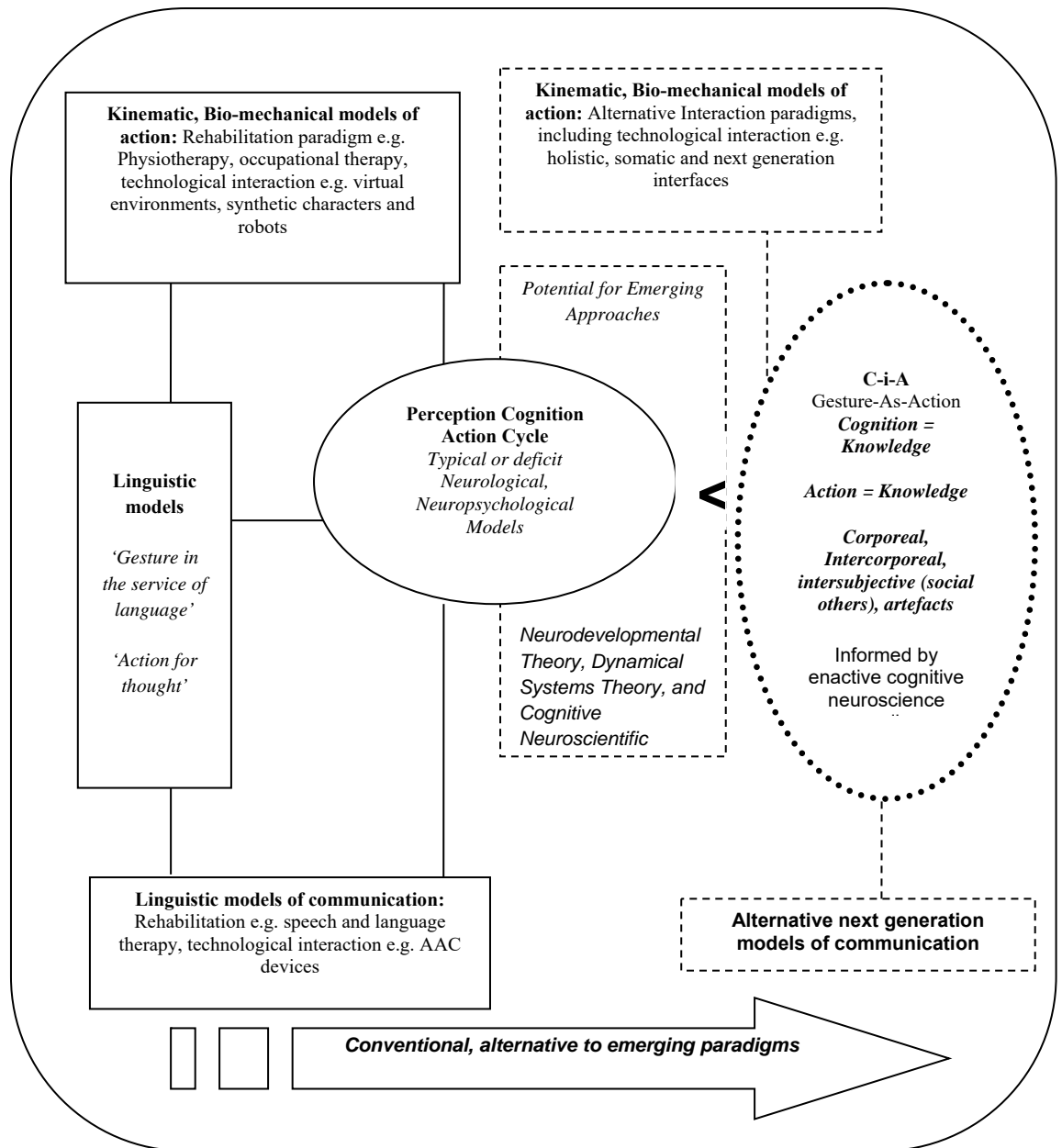


Figure A 2.1 A schematic placement of the C-i-A framework, illustrating its relationship to conventional models such as kinematic and linguistic model and practices (represented by solid lines). Alternative practice and emerging approaches and paradigms are represented by dotted lines.

Appendix Chapter 4

Supplementary Details *Interaction Protocols, Stimuli Construction for Selected Case Studies*

Condition A - Interaction Protocol for Adapted Charade

Condition A involves a charade game where the child co-participates with adults. A *word or phrase* is presented verbally as a stimulus tool to elicit enactive performance of a target gesture.

Presentation:

A word or phrase is presented verbally and the game show participant is invited to enact (act out) a response, e.g. *pretend to play the violin; sip soda; pretend to be a witch; to steal a necklace; to catch a ball, to hammer a nail, to show me you're hot, to show me a rainbow and to show me 'stripes'*.

Stimulus:

The gesture challenge is presented randomly from 141 items across 18 notional categories, presented in pseudorandom order, e.g. card shuffling. Table 4.3, illustrates the notional categories with examples. For a complete list of the gesture challenge items see appendices. Some cultural adjustments were made to the item bank, e.g. goal for grand slam in the USA. The gesture challenge item bank was developed by the author in collaboration; see Roy et al. (1992) and main body of the thesis.

Management of interaction between co-participants:

The role of the main *game participant* is taken by the co-participating child. In the case of neuro-atypical children where appropriate, other adults when present were, for example, familiar communicating partner(s) known to the child, such as their therapist or teacher. They took the role of a member of the *team*, who could offer support and take over the response, but only if requested by the child. The role of the *game-show* host was taken by the researcher who presented the gesture challenges and managed the pace of the session. The pace of the interaction is responsive to the child. Positive interaction is maintained, no negative judgement is placed on the response of the child. Any AAC communicator device is removed during the game by mutual consent. This is done as it is both consistent with the *game-play* and allows space for *corporeal enaction*. Neuro-typical children are encouraged to sit on a chair and not to respond using speech. The child is free to enact any particular gesture, omit a gesture or to improvise. However, where gestures are repeated the child is asked to keep them *'the same'*. The child is able to refuse to enact any gesture, move to the next item, request breaks and stop the game at any time should they wish to.

Duration:

Each interaction session is designed to be approximately 30 minutes long broken into 10-15 minute blocks. Each child typically completed 3 x 30-40 minutes sessions; this allows for greetings and warm-up.

Recording:

All interactions are videotaped for later analysis.

Location:

The location was either in a school room allocated by the school or in the room where the child would normally have their speech and language therapy session. For neuro-typical children the sessions took place in a living room, i.e. home environment. Due to the academic location of the researchers, the data collected from neuro-atypical that established the Child Gesture Corpus were taken in the USA. Contribution from children based in the UK and elsewhere in the EU were later added to the corpus, see appendices for details.

Case study:

Exemplar gestures are presented for two neuro-atypical young people identified by their co-participant code, NAT-CP number respectively.

Explores:

This sense-making ludic interaction explores the child's gesture repertoire for corporeal dynamic and/or narrative features, in relation to a single word or notional category

Condition B - Interaction Protocols for Narrative

These interactions were used to give access to a *narrative story-telling (enacting) experience*. Condition B involves participation in co-constructing a narrative. It has two variations B₁ and B₂. These are the re-telling of a cartoon film and the silent video vignettes. Further details for these are available from the thesis author.

Condition B. Interaction Protocol for Co-constructed Narrative

Condition B₂ is a variation on the narrative interaction. It is adapted to make the *narrative story-telling (enacting) experience* accessible for children with severe speech and motor impairment due to cerebral palsy. The interaction protocol can be described as one that is illustrative of a *co-constructed* narrative. The protocol is illustrated in the following example.

Presentation:

The child provides the enacted *gesture stream* to a story, to a *spoken narrative* provided by the co-participant (in this case study the researcher). The role of audience is taken by others, in this study a familiar therapist. This condition is designed to explore the potential extent of gestural capacity in neuro-atypical children experiencing a co-constructed narrative. This narrative interaction design aims to elicit *enaction as performance*, i.e. to encourage active corporeal engagement.

Stimulus - Co-constructed Narrative:

The oral narratives were developed by the author. They typically related to specific interests or experience of the child: conceptually framed using a familiar schemata, e.g. *a day out at the seaside; going to work; 'The birthday party'*, or fantasy story, e.g. *'The cowboy comes to town'*. There are no superfluous characters or scenes. There are opportunities for gesture repetition. A list of target gestures is provided in the appendices for this case study that presents *'The cowboy comes to town'*. For this particular case study, gestures include ones embedded from condition A.

Management of interaction between co-participants:

The pace of the interaction is responsive to the child. Positive interaction is maintained: no negative judgment is placed on the response of the child. However, where gestures are repeated the child is asked to keep them *'the same'*. The child is able to refuse to enact any gesture, move to the next item, request breaks and stop the game at any time should they wish to.

Duration:

Each interaction session is designed to be approximately 30 minutes long.

Recording:

All interactions are videotaped for later analysis.

Location:

Due to the academic location of the researchers, the data collected from neuro-atypical children that contributed to this part of child gesture corpus were located in the USA, see appendices for details.

Case study:

Exemplar gestures are presented in this thesis for one case study, a neuro-atypical child identified by their co-participant code, NAT-CP5

Explores:

This sense-making ludic interaction can be used to explore the child's gesture repertoire for corporeal dynamic and/or corporeal narrative features, in relation to a co-constructed narrative.

Condition C - Interaction Protocol for Artefact Manipulation

Condition C was developed to give children access to participatory design experiences. The aim of this ongoing research project is to actively involve children as co-participants in the design of future technology. This condition was later adapted to make such experiences accessible for neuro-typical children. The term *Kidsearcher* has been adopted to describe the role of co-participating children, see Roy et al. (1998) and Panayi et al. (2000).

Presentation:

The child participates in a design session related to the development of future interactive technology. In this case study manipulative interaction is encouraged with a range of physical artefacts. These are selected by the researchers, influenced in part by the interest of the child. The role of therapist or teacher is as a familiar and interested communication partner. This condition is designed to explore the potential extent of gestural capacity in neuro-atypical children experiencing a participatory future technology design session. This interaction design aims to elicit manipulation within imaginative play, i.e. to encourage and develop micro-gesture potentially useful for tangible interfaces.

Stimulus Artefacts:

These include toys and artefacts that afford interaction, including dramatic play, such as: pretend eating and explorative manipulation. The interactive dialogues were developed by the author and were related to specific interests or experience of the child.

Management of interaction between co-participants:

The pace of the interaction is responsive to the child. Positive interaction is maintained, no negative judgment is placed on the response of the child. However, where micro-gestures are repeated, the child is asked to keep them *'the same'*. The child is able to refuse to enact any gesture, move to the next item, request breaks and stop the game at any time should they wish to.

Duration:

Each interaction session is designed to be approximately 30 minutes long.

Recording:

All interactions are videotaped for later analysis.

Location:

Due to the academic location of the researchers the data collected from neuro-atypical children that contributed to this part of child gesture corpus were located in the USA, see appendices for details.

Case study:

Exemplar gestures are presented in the main body of the thesis for one case study, a neuro-atypical child identified by their co-participant code, NAT-CP 7.

Explores:

This sense-making ludic interaction can be used to explore the child's gesture repertoire for corporeal dynamic and/or corporeal narrative features, in relation to the manipulation of veridical or digital objects. In this case study, only veridical objects are considered for Condition C.

Appendix Chapter 5, 6 and 7

G-ABAS Tool Themes & Strands with Annotation Codes

A systematic analysis was facilitated using the G-ABAS themes and strands. Initially selected gestures were manually segmented (gesture from the original corpus were all manually segmented); only selected gesture exemplars were segmented for this analysis. G-ABAS enables gesture analysis in two phases: *Phase I Corporeal Dynamics* and *Phase II Corporeal Narrative*. Each phase can be divided into strands for micro analysis.

Phase I comprises six strands that enable annotation of body and object representation in space, the dynamics of action representation and manipulation and features that inform the interaction. Phase II allows for annotation of narrative features of gesture also divided into 5 strands: sources of narrative knowledge, deictic, coherence and fidelity, abstract, emotion. The analyses are presented in the analysis chapter (4 onwards). The phases of coding and annotation have been simplified and illustrated schematically together with stages, themes and strands of G-ABAS Ontology; see Figure A.5.1. and Figure A.5.2. Gestures are manually segmented. Descriptors are used with annotation code for establishing initial and progressively detailed features, e.g. corporeal zone, gesture phrase - beginning and end of gesture. Progressive viewings consider points of interest

The sections that follow describe each phase in detailed tables with descriptors and codes. The abbreviations for G-ABAS, glossary for the codes and sample annotation sheets have been provided in the appendix 3.

1. Phase One Corporeal Dynamic Features

Action abstraction, representation, manipulation, interaction description and emotion

This phase deals with five main strands of analysis of action representation and manipulation features, together with a measure of gestural dynamics (GDYN), derived from each level 1-6. There is also a scale of level of involvement (LIND-G 1-6). Strand 1 has annotation for the abstraction of the action, e.g. AOA. Strand 2 for the annotation of *how* the action is manipulated, e.g. MO]. The third strand allows for representation of the self and other, i.e. object and person [ROA]. Strand 4 enables the annotation of the interaction [ID] in a variety of narrative contexts. Strand 5 codes for emotional nature of corporeal dynamics. These are summarised as follows:

1. *Abstraction for Action [AOA]*
2. *Manipulation of Action [MOA]*
3. *Representation of Object & Person [ROA] and*
4. *Interaction Description [ID] in a variety of narrative ecologies of interaction*
5. *Emotion [E]*

A measure of Gestural Dynamics [GDYN] can be derived from each of the levels 1-5. During the first iteration of the data the annotation allows coding for level of corporeal zone involvement, Chart ZI a. The principle zone of corporeal involvement [ZI], has been informed by Bacons' Sphere (adapted for this study); Figure 3.3.2, but limited to zones 1-4 in the first instance. Corporeal descriptions of Primary zones have been developed after Thwing (1876) and extensive detail for coding and annotation of Z1 Head, facial expression and nose, Z2 Arm, torso, wrist hand and fingers can be found in the appendix. The level of independent involvement in gestural performance (LIND-G) is described on a numerical scale as follows and illustrated below (Chart Z1c). Chart ZI a Shows Four Principles Zones of Body Space Involvement: *16 clusters. Charts ZI b shows extended corporeal narrative features for hand, fingers (17 features) and arms (17 Features); Chart Z I c shows the levels of independent Involvement in Gestural Performance (6 Levels) and Chart ZI d Twelve Principle features (6) and (6) strategies summarised for a first level analysis.*

The section continues with a listing of features clustered by strands and presented sequentially in charts. Each chart indicates the type by abbreviation and description of each individual gestural features; the

total number of features for each strand is given at the beginning of the chart. The strands are presented sequentially for each phase as follows:

Phase One Corporeal Dynamic Feature Themes and Sub-theme Clusters

Chart ZI a Principle Zones of Body Space Involvement *16 Features,*

Charts ZI b *extended for corporeal narrative hand, fingers (17 features) and arms (17 Features)*

Chart ZI c Levels of independent Involvement in Gestural Performance (6 Levels)

Chart ZI d Twelve Principle features (6) and (6) strategies summarised for a first level analysis

Strand 1. Abstraction of Action [AOA]

Chart CD 1 a Location *5 Features*

Chart CD 1 b Path & Directionality *10 Features*

Chart CD 1 c Representation Schema *6 Features Total 21*

Strand 2. Manipulations of Action [MOA]

Chart CD 2 a Object Transformations *5 Features*

Chart CD 2 b Self/Person Transformations *4 Features Total 9*

Strand 3. Object Representation both Imaginary and Veridical [IOR] [ROR]

Chart CD 3 a Imaginary Object Representation *5 Features*

Chart CD 3 b Veridical Object Representation *5 Features Total 10*

Strand 4. Interaction Descriptions [ID]

Chart CD 4 a Action Geometry *14 Features*

Chart CD 4 b Kinematics & Manner *26 Features*

Chart CD 4 c Granularity 2 + Componential *2 Features*

Chart CD 4 d Scene Space *3 Features*

Chart CD 4 e Emotion salience *22 Features Total 67*

Figure A.5.1 G-ABAS ONTOLOGY
GESTURAL ACTION COMPLEXITY
Themes (2), Strands (10), Clusters (36), (260) Features

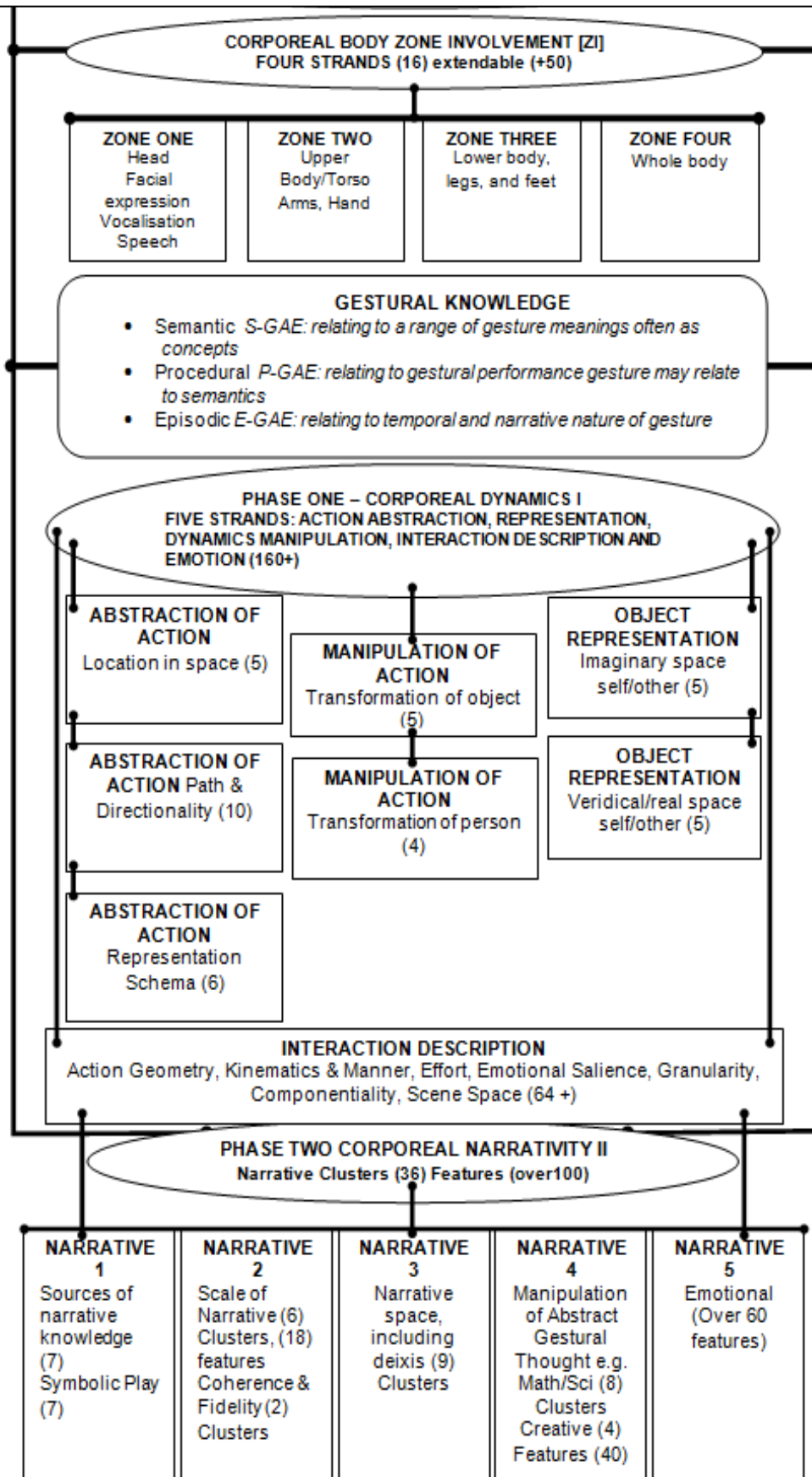


Chart ZI a Four Principles Zones of Body Space Involvement *16 clusters*

G-ABAS Abbrev.	ZONE INVOLVEMENT [ZI]
	ZONE ONE
H	head
FX	Facial expression
EB	Eye brow movement
E	Eye movement
V	Vocalisation
S	Speech
	ZONE TWO
A	Arm
SIG-UBT	Significant upper body/torso
W	wrist
HG	Hand gesture
FG	Fingers
	ZONE THREE
LBOD	Lower Body
SLG	Significant Leg
SFT	Significant Foot
	ZONE FOUR -
SIG-WBG	Significant whole body gesture
GR	Generic gestural response

Chart ZI b Z1, Z2 Extended, *36 Features* under development

Figure A.5.2 A schematic of gestural interaction, located in the imaginary corporeal sphere with intersects and zones of interactive space and body zones Z1-4 G-ABAS, inspired after Bacon's 'Manual Gesture' see also main thesis.

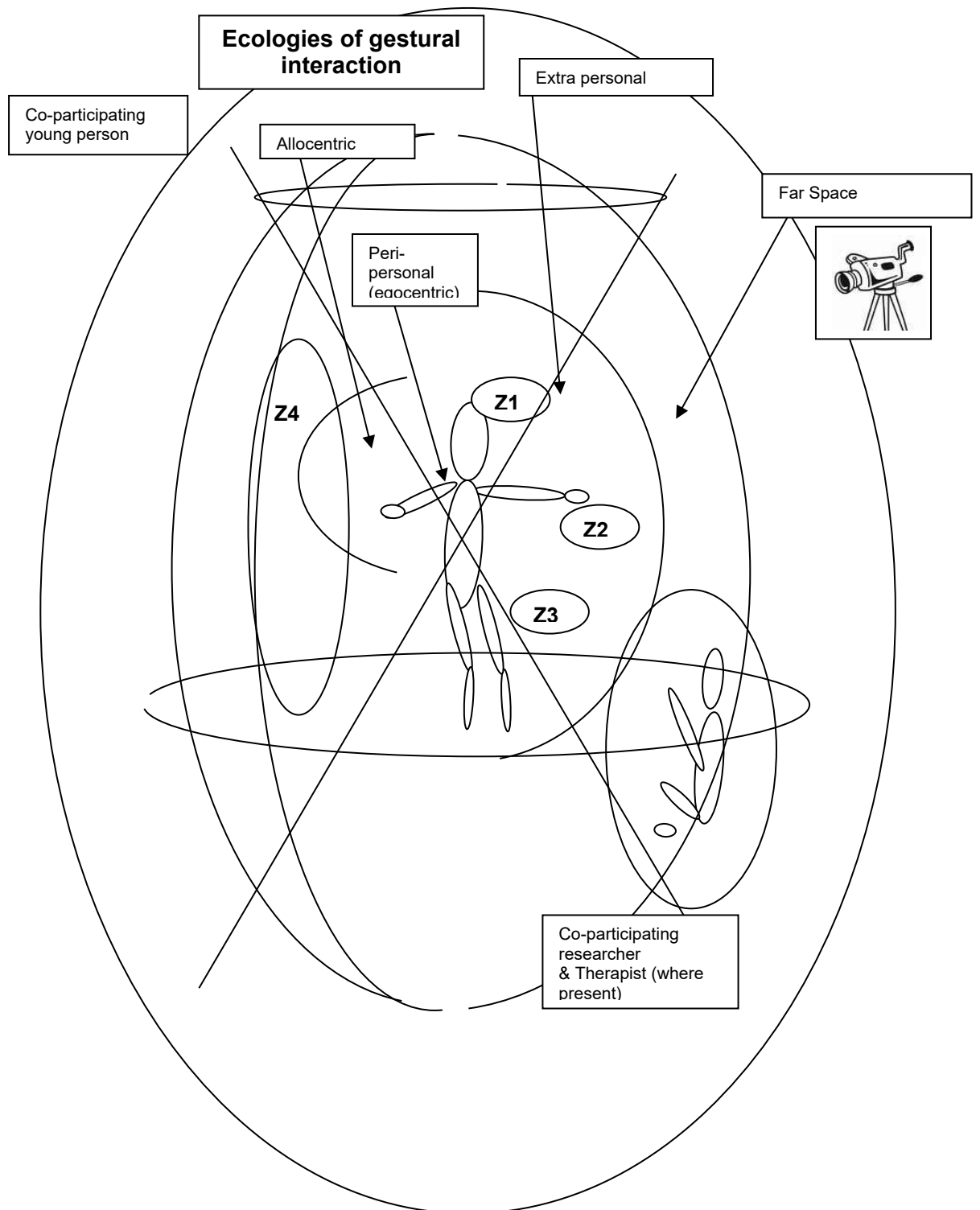


Chart Z I c Levels of independent Involvement in Gestural Performance

Numerical Scale	Involvement of gestural response
1	No gestural response
2	Physical prompting required
3	Gestural prompting required
4	Verbal prompt required
5	Independent gesture produced
6	Novel gesture

Chart ZI d Twelve Principle features including strategies summarised for a first level analysis

1	SE-RO Body represents real object of SE -Pt RO part of object
2	SE-VO Body represents imaginary object of SE -Pt VO part of object
3	I-VO Interaction with imaginary object/phenomenon or I-PtVO part of object/phenomenon
4	I-RO Interaction with real object/phenomenon or I-PtRO part of object/phenomenon
5	A-VO Second/additional imaginary object/phenomenon is evoked
6	TRANS- Transformation of any of the features 1-5
7	EPCP Enaction of physical phenomenon or consequence of physical phenomenon
8	MMG micro/macro gesture including Deictic DT
9	PCMSU Particular Co-ordinated Motor strategy use e.g. (DWCML) difficulty with crossing midline
10	DS Dysarthric speech, or NSp natural Co-Speech
11	ENPCP narrative phenomena or consequence of narrative phenomenon
12	PDCG Progressively dynamically changing complex gesture

Strand 1. Abstraction of Action [AOA]

Abstraction of Action can code for spatiality in terms of Location (5 features) Chart CD1a, Chart CD1b Path and directionality (10 features) and Action representations schema, Chart CD 1c (6 features).

Chart CD1 a Location *5 Features*

GABAS Abbrev.	ABSTRACTION OF ACTION LOCATION
EC	Egocentric/Eccentric from centre
AC	All centric
PP	Peripersonal
P	Proximal
D	Distal

Chart CD 1 b Path & Directionality *10 Features*

GABAS Abbrev.	ABSTRACTION OF ACTION TRACE PATH & DIRECTIONALITY
L	Left
R	Right
T	turn/rotation
TFML	turn from mid line
TW	towards
OW	outwards
IW	inwards
SU	surface
SII	Size indicator
CUR	Curvature

Chart CD 1 c Representation Schema *6 Features*

GABAS Abbrev.	ABSTRACTION OF ACTION REPRESENTATION SCHEMA
SE SP	Self and Spatiality e.g. location, agency of action, relational
OBJ	Object real [R], [V] virtual or imaginary [I]
OBJ – OTH	Other i.e. other agent as person or phenomenon
OBJ-R	Object Recognition Representation of object features related to interactivity e.g. physical, spatial, relational
OBJ -F	Functionality e.g. agency of action, containment
OBJ-TW	The world Interactivity in terms of timeframes, past, present, future

Strand 2 Manipulations of Action [MOA]

Annotates for transformation of object/artefact [MOA-O, Chart CD2 a (*5 features*)] and person [MOA-P], Chart CD 2 b (*4 features*).

Chart CD2 a Object Transformations *5 Feature*

GABAS Abbrev. OBJ-TRANS	MANIPULATION OF ACTION [MOA-OBJ] OBJECT TRANSFORMATIONS
OBJ-TO	Object to different object
OBJ-TRP	Object to real person
OBJ-TVP	Object to virtual person
OBJ-TPt RO	Object to part of real object
OBJ-TPt VO	Object to part of virtual object

Chart CD2 b Person Transformations *4 Features*

GABAS Abbrev. SE-TRANS	MANIPULATION OF ACTION [MOA-SE] SELF OR OTHER PERSON TRANSFORMATIONS
SE-O	Self or other person to object
SE-AP	Self or other person to additional person
SE-PtRO	Self or other person to part of real object
SE-PtVO	Self or other person to part of virtual object

Strand 3 Object Representation both Imaginary and veridical

Annotates for the representation of both real (veridical) object [ROR] and Imaginary [IOR] Chart CD 3 a (5 features) and or veridical [ROR], objects [OR] Chart CD 3 b (5 features). The creation of 'tertiary' artefacts or phenomena is discussed in Phase II Corporeal Narrative in strand 4 that enables the annotation of aspects of abstract gesture.

Chart CD3 a Imaginary Object Representation *5 Features*

OBJECT REPRESENTATION [IOR]	
GABAS Abbreviation OBJ-REP-V	IMAGINARY INTERACTIVITY
OBJ-VO	Virtual object
OBJ-PtVO	Part of virtual object
INT+ VO	Interaction with virtual object
A+VO	Second or additional virtual object/phenomenon
Q+VO	Quality of the virtual object (s)

Chart CD 3 b Veridical Object Representation *5 Features*

OBJECT REPRESENTATION [ROR]	
GABAS Abbreviation OBJ-R	VERIDICAL INTERACTIVITY
OBJ-RO	Object
OBJ-Pt RO	Part of Object
I+RO	Interaction with real object
A+O	Second or additional object involved
Q+RO	Quality of the real object

Strands 4 Interaction Description [ID]

The interaction descriptions codes enable the annotation of the Action Geometry, Chart CD 4a (14 gestures), Kinematics & Manner Chart CD4b (21 features), Granularity and componential nature of the action, Chart CD 4 c (5 Features) together with Emotional Saliency, Chart CD 4 d (3 features) and features of Scene Space, Chart CD 4e (3 features).

Chart CD 4d in particular brings together features in the context of emotional saliency and was extended and derived from the early work of Adams (1891), summarised from eleven principles of pantomime and Thwing (1876) extract from a very large description of gesture, introduced in Chapters 1 and 2. Gestural features are coded in relation to principle or motion, velocity, altitude, form, force, reaction, sequence, climax, number and duration, grace and opposition

Chart CD4 a Action Geometry 14 features

GABAS Abbrev.	GEOMETRY
	Volume
VOD	Volume/dimension
B	Boundary
DTH	Depth
HT	Height
WTH	Width
CIRC	Circumference
PRMT	Perimeter
	Shape
SQ	Square
TRI	Triangle
CONC	Canonical
OGSP	Other geometric shapes
	Axis
SL	Straight line
CUR	Curvature
CRV	Crossed vectors

Chart CD 4 b Kinematics & Manner *26 features*

GABAS Abbrev.	KINEMATICS & MANNER
SPACE	Space expressed as direct action and indirect action.
-DIR+	DIR-direct action
-IND+	IND-indirect action.
TEMP+	Temporality coupled with sudden or sustained action
SUDD	Sudden action
SUST	Sustained action
SP	Speed
ACC	Acceleration
DEC	Deceleration
IM	Impact
TRAJ	Trajectory
TRANS	Transformation of action happens at points of non-zero velocity, non-zero acceleration
PH	Phased
REP	Repetitive
DYN	Continuous dynamic
SHIFT	Movement shift
STAT	Static/suspended; zero velocity, zero acceleration
POSE	Pose; zero velocity and acceleration
BIMAN	Bimanual can be code of alternative effectors e.g. foot (neuro-atypical children)
UNIMAN	Uni-manual
SYM	Symmetry
ASYM	Asymmetry
EFF	Effort
WT	Weight HWT+ Heavy weight, LWT=light weight
FLOW	Flow happens with non-zero velocity, zero acceleration B Bound, FLOW – F Free

Chart CD 4 c Granularity 2 + Componential *2 Features*

GABAS Abbrev.	GRAULARITY
MIM =	micro movement
MAM=	macro movement
	COMPONENTIALITY
+	with
-	without
t	to

Chart CD 4 d Scene Space *3 Features*

GABAS Abbrev.	SCENE SPACE
[VSS]	VERIDICAL Space in the real world
[ISS]	IMAGINARY Spaces of the imagination
[HSS]	HYBRID Spaces that bridge the real and imaginary world e.g. with artefacts including technology mediate spaces.

Chart CD 4 e. Emotional salience 22 Features

Extended by interpretation from eleven principles of pantomime, after Adams (1891) where the gestural features are described in relation to principle or motion, velocity, altitude, form, force, reaction, sequence, climax, number and duration, grace and opposition.

GABAS Abbrev.	EMOTION SALIENCE (selected features after Izzard, Adams)
EMS- Vital	Eccentric Vital or explosive form of passion Intense passion
EMS- INTENSE	Concentric Intense passion
EMS- NORM- POISED	Normal or Poised Possessed form of passion
EMS – VEL	Proportional to mass moved and force moving. Proportional to depth and majesty of the emotion e.g. slowness vs. acceleration, c.f. Heavy vs. light
EMS- ALTI -HI -LOW	Positive – high - Emotion rises Negative – low - Emotion falls
EMS- FORM -ST -CIR -SPIRAL	Straight line - Vital and strong Circular lines- Mental and reflective Spiral- Spiritual and mystic
EMS-FORCE -STRONG -WEAK	Strength Assumes strong attitudes Weakness Assumes weak attitudes
EMS-REACT -SUPP -EXP	<i>Reaction</i> Suppression/concentration to explosion c.f. Explosive/vehement emotion to prostration Extremes of emotion tend to react to its opposite
EMS - SEQ	<i>Sequence</i> Facial expression precedes gesture, gesture precedes speech
EMS - CLIMAX	<i>Climax</i> Typically expressed in the face, for maximum effect allow a small reserve of energy
EMS- No and DUR	<i>Number and duration of gesture</i> Every gesture is an expression of the effect produced of some expression Gesture duration can be held to sustain the impression
EMS – GRACE -EASE -PREC -HARM	<i>Grace</i> The blending of three elements – ease, precision and harmony Too great ease of manner or action leads to assurance, vulgarity and familiarity vs. Too precise action or manner leads to mechanical action and stiffness Leads to affectation and sickens and disgusts the spectator Super abundance of harmony
EMS- OPPOSE	Opposition Arrangement of parts around the centre of gravity In opposition lie all the symmetry and harmony of motion Opposite movements must be simultaneous Parallel movements may be successive Greater number of agents brought into play the higher the form of expression

2 Phase Two Corporeal Narrative

The theoretical underpinnings of this phase have been described in detail in chapter 1 & 2. These five strands allow for the examination of narrative gesture patterns in terms of clusters and features. **Narrative Strand 1:** Source of narrative knowledge, Chart CN 1 (clusters 7), together with Coherence and Fidelity **Narrative Strand 2;** Chart CN2 (clusters 2). **Narrative Strand 3** provides 11 clusters that examine gesture space across interactional, local and narrative space, including aspect of deixis, Chart CN3, developed after Havilland and Herman. Importantly for the work of this thesis two aspects are of particular relevance when considering gesture in narrative space during *'enactments'*: point of view (POV) and deictic field (DF). Firstly, *'point of view or perspective'*, is defined by the character (POV) (c.f. Constructed action, CA in sign). Secondly, the deictic field is the space where the gesture is most salient and may involve the agents of interaction/communication, Deictic gestures incorporate zero point of reference *'origo'* (term after Bühler 1934). The features in this cluster can be combined with corporeal dynamic of gestures. **Narrative Strand 4**, Manipulation of Abstract Gesture Thought describes schema and procedural generalizations (gesture functions). Similarly, features in this strand can be combined with kinematic features to convey the narrative *'texture'*, such as time, space and mathematical and scientific schema. Of particular significance to this thesis is the capacity of gesture functions to create a *'tertiary'* artefact where gestures are used both to represent and to manipulate models. These models are often imaginary or combined (hybrid) with drawing (2D contact gesture) or interaction with a primary artefact i.e. one in veridical space. Such abilities enable children to both communicate in an immediate sense (Bartolini et al, 1999) and to solve problems using *'factual generalization'* (Radford, 2003). Various sources form the domain of creative arts, e.g. dance, visual design; artistic creative manipulations provide further clusters features. For example in combination with features from Charts CD 1-4 corporeal dynamics theme, to reveal dynamic manipulations in Manipulation of Creative Abstract Gestural Thought (developed after Garrett 1967 134,113 cited Herbison). **Narrative Strand 5** considers the physicality of emotion through coding for expressive posture once again using features of velocity, acceleration and effort (derived after Adams, Laban) Chart CN5 (3 Main featural categories).

Schematics that summarize aspects of Narrative Theory as applied to this work can be found in the main body of the thesis. Aspects of Narrative Theory are used to inform the development, validation and evaluation of the SCA Model (chapters 6, 7) and provide a structure to deal with gestural complexity. The strands are presented in the order as follows:

Phase Two Corporeal Narrative Gesture Features Themes and Sub-theme Clusters

Narrative Strand 1 Sources of Narrative Knowledge

Chart CN1 Sources of Narrative Knowledge **7 clusters**

Narrative Strand 2 Narrative Knowledge

Chart CN 2a Scales of Narrative Knowledge **6 Clusters, 18 Features**

Chart CN2b Coherence & Fidelity **2 Clusters**

Narrative Strand 3 Narrative Gesture Space includes deictic feature across Interactional, local and narrative space

Chart CN 3 Narrative Gesture Space: Interactional, local and narrative space. These features are presented in my thesis during 'enactments' from the point of view [POV] of the principle character. **9 Clusters**

Narrative Strand 4 Manipulation of Abstract Gestural Thought

Chart CN 4 1-1.4 Combine features to reveal dynamic manipulations – see charts 1-4 corporeal dynamics. Application in mathematical/scientific and creative arts thinking (not shown) *under further development.*

Chart CN 4 1.2 a **Manipulation of Abstract Mathematical/Scientific Gesture** Schema and generalization (see Edwards; Goldin-Meadow for co-speech use of these ideas)

8 Clusters

Chart CN4 1.2 b **Manipulation of Abstract Gestural Thought – Creative**

4 Clusters (40 features)

Narrative 5 Emotional Gesture

Chart CN 5 Emotional Descriptor **2 Clusters**

Chart CN 5.1 series – 5.2 expand the coding and annotation for over 60 emotional gestural features *under further development.*

Narrative Strand 1

Chart CN1 a Sources of Narrative Knowledge **7 Clusters**

GABAS Abbrev	Feature Descriptor
NARR [I]	Imagination as the point of intersection where narrative experience has continuity having both social and personal meaning, after Dewey ' <i>a continuum, that of "imagined now, some imagined past, or some imagined future."</i>
NARR [FTXT]	Field Texts use of as data sources specifically for this study: field notes, interviews, family stories, photos and other artefacts
NARR [HK]	Human Knowledge a focus on organization of rather than the mere collection and processing of data
NARR [M] NARR [P]	Narrative as both phenomena under study and method of study
NARR [EPM-HK]	'Unquantifiable' or 'Ephemeral' gestural knowledge including experience can be communicated through (after Clandin & Connelly, Panayi)
NARR-B	Narrative Binding as (second hand information) to cognitive issue of memory (first hand perception) can both be constructed and re-perceived (modified after Bruner, Clark)

Chart CN1 b

Strand Narrative Knowledge Symbolic Play *7 Feature levels*

Play Classified according to complexity in natural sequence of child development; see McCune-Nicolich (1981) for original categories of symbolic play.

G-ABAS Abbrev.	Feature descriptor Type of play, level
NARR-PSP- EXP	Pre-symbolic 1st level Represents exploratory play. Child shows understanding of object through ' <i>recognitory</i> ' gesture. Property of object can be the stimulus for action, e.g. may include sensory motor meaning, may show with some or no symbolic ' <i>pretending</i> ' function
NARR-ASP- ACT-SELF	Auto-symbolic 2nd level Situations in which child acts upon him/herself, shows a level of pretence, e.g. sleeping, eating, grooming
NARR-ASS- SP-ACT- OTHER	Assimilative symbolic play 3rd level Occurs when child applies action and pretend activities to another actor or object, e.g. person or doll
NARR-IMI- SP-ROLE CHG	Imitative symbolic play 4 th level Occurs when the child imitates the action of others and is capable of changing their role
NARR-SP- SUB OBJ	Symbolic play with a substitute object 5th level Occurs when the child substitutes one object with another based on needs, features may be arbitrary.
NARR-SIM + SP	Simple combinatorial symbolic play 6th level Occurs when child applies an action to a different ' <i>receiver</i> '. This may involve single symbolic scheme applied to several participants, e.g. feeding people at the seaside and multiple symbolic scheme where two successive actions are played in sequence, e.g. feeding people at seaside and catching more 'fish'
NARR-MULT +SP	Multiple combinatorial symbolic play 7th level Occurs when the child applies different actions to a single ' <i>receiver</i> ' Requires the co-ordination of at least two ' <i>representational structures as covert mental transformations</i> ' or ' <i>intention which directs pretend behaviour</i> ' or there may be evidence of planning of pretend action, e.g. hands to mid line to ride an imaginary horse

Narrative Strand 2a

Chart CN2a Scales of Narrative Knowledge 6 Clusters, 18 Features

G-ABAS Abbrev	Descriptor & Notes
NARR-THEME	Theme: The main event of the narrative is explicitly portrayed 1: Integrated with the protagonist action 2: Portrayed more than once 3: Not portrayed
NARR-PLOT	Plot 1: All components portrayed 2: Some components portrayed 3: No components portrayed
NARR-ELAB	Elaboration Gesturer attributes internal states to protagonist 1. Extensive use of evaluative: causal, emotional terms, hedges and mental verbs, range of conjunctions 2. Few mentions of evaluatives 3. No mention
NARR- EVAL	Evaluation Gesturer mentions each of the events and elaborates on them 1. Rich description of events, includes all episodes 2. Most episodes, little description 3. Few episodes, no elaboration
NARR- STORINESS	Storiness Use of series of gestures to integrate events in to narrative 1. Use of a variety of gesture types 2. Limited no of gesture types 3. No use of linked gestures
NARR- REFER	Reference Referents are clearly established 1. Clearly established 2. Some ambiguity 3. Frequent ambiguity

Narrative Strand 2b

Chart CN2b Coherence & Fidelity 2 Clusters

GABAS Abbreviation	Feature Descriptor
NARR [COH]	Coherence Concerned with the understanding of structure, detail and character. In this study relates to the construct in GAA as self, the other and the world.
NARR [FID]	Fidelity Concerned with story truth, includes values, relevance, consequence, transcendence. In this study this is applied more broadly to encompass the concept of fidelity of gestural action

Narrative Strand 3 Narrative Gesture Space includes deictic feature across Interactional, local and narrative space
 Chart CN 3 Narrative Gesture Space: Interactional, local and narrative space. These features are presented in this thesis during 'enactments' from the point of view [POV] of the principal character and relevance of deictic field *9 Clusters*

GABAS Abbreviation	Narrative Gesture Space and Deictic feature descriptor
1 NAAR-GRD	Grounded <i>HERE & NOW local space</i>
2 NARR-EXT	Extended <i>Not perceptible but discoverable in local space</i>
3 NARR -SW	Story-world <i>THEN & NOW environment narrative space</i>
4 NARR-META	Meta-narrative <i>Clarify status, position, identify (object, event or participant) in narrative space</i>
5 NARR-SPACE TRANS ISS, VSS, HSS	Transformations in narrative space. Status for scene space imaginary –ISS to veridical (real) VSS and hybrid –HSS
6 NARR-UNDS	Understanding of the interlocutor's contribution. This focus could be –DIR or IND <i>in interactional space</i>
7 NARR-CONM	Continuation marker Teller's intent to continue <i>Interactional space</i>
8 NARR-COMM	Completion marker Mark of teller's completion <i>Interactional space</i>
9 NARR-ENRC	Enacted recall
Note: The point of view – is defined by the character (POV) c.f. Constructed action in sign {CA} Deictic (pointing) gestures typically have a zero point of reference 'origo' (term after Buhler 1934) and deictic field (space where the gesture is salient may involve the agents of interaction/communication).	

Narrative Strand 4 Manipulation of Abstract Gestural Thought – Mathematical /Scientific

Chart CN 4 Combine features to reveal dynamic manipulations – see charts 1-4 corporeal dynamics. Application in mathematical/scientific and creative arts thinking

Chart CN 4 a1.2 Manipulation of Abstract Mathematical/Scientific Gesture. Schema and generalization (see also Edwards; Goldin-Meadow for co-speech gesture analysis) *8 Clusters*

G-ABAS Abbrev.	MAT-G	Manipulation Abstract Gestural thought e.g. Mathematical /scientific Gesture
Schema		
MAGT--RO		Object
MAGT-RP/MOT/EVENT		Procedure/motion/event
MAGT-RDESCP.		Physical Description
MATG-RREL		Relationship
MATG- AB-O		Imaginary/Abstract Object
MAGT-FG		Manipulation of Abstract Function (Factual generalization)
MAGT-FG AP		Imaginary/Abstract Procedure
MAGT-FG AR		Imaginary/Abstract Relationship
MAGT-FG EX		Imaginary/Abstract External Relationship

Chart CN4 1.2 b Manipulation of Abstract Gestural Thought – Creative

4 Main feature categories (over 40 Features potentially in combination, see ontological map)

Abstract Narrative Abbreviation	Manipulation of Abstract Gestural Thought – Creative
MAGT -VD-BQ	Elements of visual design and basic qualities
MAGT-VD- MAN/ORG	Aspects of manipulation, structure and organization
MAGT- ACM-BQ	Elements of Artist/Creative basic qualities
MAGT-ACM- MAN/ORG	Aspects of manipulation, structure and organization

Narrative 5 Emotional Gesture

Chart CN 5.1 a Emotional Descriptor 2 Clusters

GABAS Abbreviation	Emotional Descriptor
NARR -EM	Emotional Descriptor
NARR -EM-SCENE	Emotional Posture on 'stage'/scene Emotions vs. Dance pose figure (created after Humphrey), combine with Corporeal features chart 4d (3 clusters)
NARR-EM-DYNAMICS IN PERFORMANCE	Emotional Dynamics with Corporeal features chart 4a,b,e Saliency (62 features)

Chart CN 5.1 series – 5.2 expand coding and annotation for over 60 emotional gestural features under development.

3 Phase Three Corporeal Intelligence

Spatial Kinaesthetic Interaction & Intelligence Profile [SKIP]

Measures are being developed by combining data from the analysis of features from gestural repertoires. These measures can be used in conjunction with the Cognition in Action conceptual framework (C-i-A) to support the development of individualized pedagogic/rehabilitation programmes for young people with physical and cognitive challenges. Such measures can be used to show progression and to identify areas for more intensive work. The Spatial Kinaesthetic Interaction and Intelligence Profile SKIP is being developed to include '*Cognitive Capacity*' measures, e.g. number of notional categories with positive response, number of responses in given scenario/series. In addition '*Competency measures*' would give details of achievement of gesture response across all scenario/series of interactions. Specific details could reflect kinaesthetic Intelligence (KI) that acknowledges physical capabilities, e.g. use of body space, level of involvement. Potential Meta Cognitive Indicators could be derived as they are revealed through children's gestural repertoires across the three broad categories of GAE (S-GAE, P-GAE and E-GAE). Features may include for example:

- *notional category*
- *kinematic motion features*
- *object representation/classification/association*
- *motion comparatives (e.g. reveal through gestural expression of understanding of through verbs and nouns of motion)*
- *comprehension of topological space (i.e. physical - Egocentric, Allocentric, navigational and metaphoric (e.g. time, space))*
- *combinatorial features*
- *narrative complexity*

These features together a notion of '*fluid and crystallized intelligence*' could be used to indicate young people's understanding of non-verbal interaction both internally (memory/imagery) and externally through gestural interaction in the real world. For simplicity, a series of visual G-ABAS observational profile templates are being developed for use in pedagogic and therapeutic settings (see schematic Figure A.5.3). In summary a visual map with video samples (SKIP 1) can be used to establish the communicative and interaction environments for neuro-atypical communicators and movers. In conjunction with existing reports that may be available for the child, this forms the starting point for the SKIP. Following exposure to a gestural interaction programme, the gestural ability of the child is mapped onto the second (SKIP 2). SKIP 3 is a template that tracks the child's progress in terms of selected dynamic aspects of Cognition as Action. Progression from SKIP1-2-3 can be used to highlight key areas for the development of individualised or group programme of intervention that can be discussed with the child and people they work with (Panayi, in prep, 2014). This section should be read in conjunction with Chapters 1, 2, 6 and 7 of the main thesis.

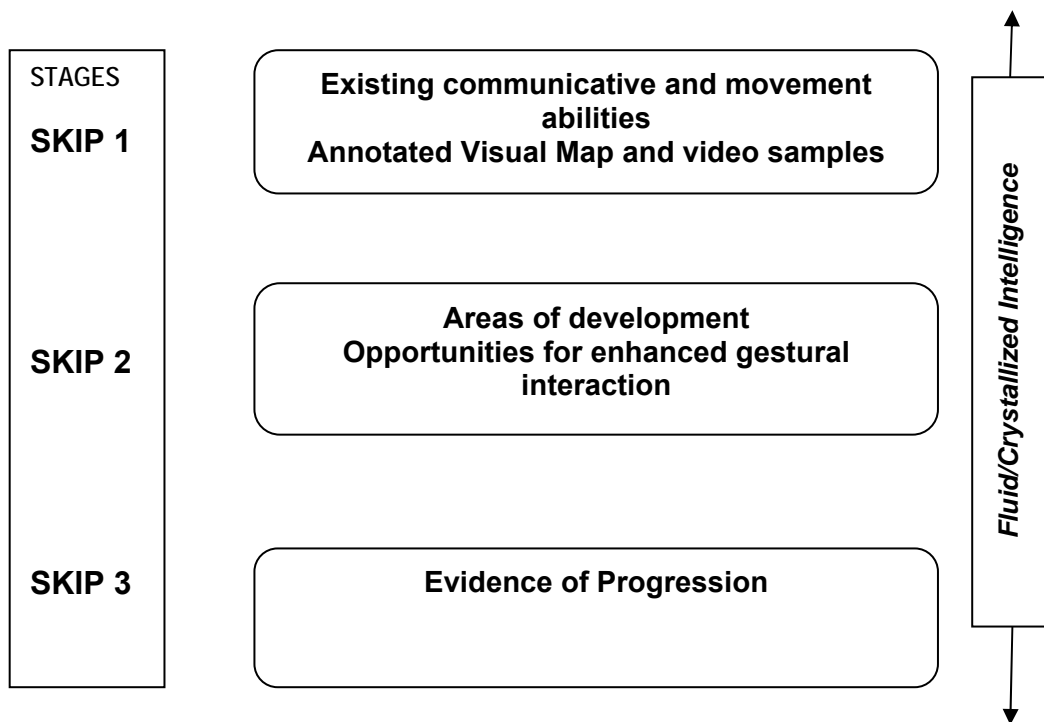


Figure A5.3 Fluid/Crystallized intelligence paradigm for developing children's' skills and habits supported by the Cognition-in-Action conceptual framework.

Child Gesture Corpus Media Clips Data Extracts ©2014 M. Panayi, PhD. 'Cognition in Action'.

Ethics Declaration: Please note media clips on the associated disk are for reference only for the examiners and not for public distribution. The extract sheet can be published as can the media images embedded in the thesis document.

Media Editor Credit thanks to: A. Roy

Notes: 11 Clip Media

Notation: Co-participant code_Ludic condition_gesture exemplar for *Condition A adapted charade* and for *Condition B: Co-Constructed Narrative* sequence extract the brackets indicate [end gesture exemplar]. For *Condition C: Manipulation of Artefacts* the interaction artefact is specified in place of the gesture locator, i.e. Jelly Mould. Additional media clips for neuro-typical exemplars have been included for illustrative purposes for Condition A (Co-participant: SNT2), referenced as: SNT2_A_bell. "Pretend to press a bell" is the start gesture exemplar in the charade sequence. Condition B: *Narrative Cartoon -retelling* and Condition B1: *Narrative Silent Vignette*.

[Condition A: Adapted Charade Game – SNAT-CP9_A_Violin](#)

[Condition A: Adapted Charade Game – SNAT-CP9_A_Cat](#)

[Condition A: Adapted Charade Game – SNAT-CP9_A_Lasso](#)

[Condition A: Adapted Charade Game – SNT1_A_Lasso](#)

[Condition A: Adapted Charade Game – SNT1_A_Spider_Cat](#)

[Condition A: Adapted Charade Game – SNT2_A_Bell](#)

[Condition B: Narrative Cartoon Film – SNT1_B_Post](#)

[Condition B1: Narrative Silent Vignette – SNT2_B1_Barndoor](#)

[Condition B1: Narrative Silent Vignette – SNT2_B1_Tape](#)

[Condition B2: Narrative Co-constructed – SNAT-CP5_B2_\[Beard\]](#)

[Condition C: Manipulation Of Artefact Narrative Co-constructed – SNAT-CP7_C_JellyMould](#)



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Glossary

NOTES Two terms are often used interchangeably in literature; they are introduced here to clarify the scope of the terminological used within the context of my thesis. The terms *cognition* and *action* are defined in their extended form within the theoretical underpinnings of the C-i-A framework. Simpler definitions can be found in the introduction. This glossary has been edited and compiled from various sources including wordnet.princeton.edu/perl/webwn, Wikipedia and the author's own resources.

Cognition: *Concerning the mental process of acquiring knowledge and understanding through thought, experience, and the senses. These include attention, remembering, language and problem solving.*

Encompasses all of the above and extends to include: *where the mental process of acquiring is inseparably and intimately interconnected with the biologically embodied entity of the organism (self) and the other (person(s) or artefact(s), within any give environment or ecology. This interactivity encompassed the real (veridical), the imaginary and hybrid worlds, A hybrid world is one that is at the interface of the veridical and imaginary and/or is mediated by intimate interaction with technology,*

Action: *Concerning the processes causing intentional human bodily movements, a way of motion or functioning, when it takes account of others (i.e. social), when it is an attribute of the dynamics of a physical system.*

Encompasses all of the above and extends to include: *when it is an attribute of dynamic biological systems and is considered within the enactivist paradigm*

Alphabetical List

Abduction: is a form of logical inference that goes from *data description of something to a hypothesis that accounts for the reliable data and seeks to explain relevant evidence*. The premises do not guarantee the conclusion; can be understood as "inference to the best explanation".

Abstraction: the process of formulating general concepts by abstracting common properties of instances 2. a precise rule (or set of rules) specifying how to solve some problem 3. a general concept formed by extracting common features from specific examples wordnetweb.princeton.edu/perl/webwn

Allegorical: interpreting narratives as having a level of reference beyond the explicit

Autopoiesis: 'literally means "auto (self)-creation" (from the Greek: *auto* – *αυτό* for self- and *poiesis* – *ποίησις* for creation or production), and expresses a fundamental dialectic between structure and function.

The term was originally introduced by Chilean biologists Humberto Maturana and Francisco Varela in 1974

'... An autopoietic system is autonomous and operationally closed, in the sense that there are sufficient processes within it to maintain the whole. Autopoietic systems are 'structurally coupled' with their medium, embedded in a dynamic of changes that can be recalled as sensory-motor coupling. This continuous dynamic is considered as at least a rudimentary form of knowledge or cognition and can be observed throughout life-forms; broad sense as including basic perceptual, motor-program, emotional, historical, social and linguistic dimensions.'

Coding: as content analysis according to categories deemed important. In this study the categories are clustered around two phases of corporeality dynamics and narrative. <http://faculty.chass.ncsu.edu/garson/PA765/narrativ.html>

Cognitive semantics: is part of the cognitive linguistics movement. The main tenets of cognitive semantics are, first, that grammar is conceptualization; second, that conceptual structure is embodied and motivated by usage; and third, that the ability to use language draws

upon general cognitive resources and not a special language see also Semasiology – branch of study concerned with aspects of meaning

Coherence: logical and orderly and consistent relation of parts
wordnetweb.princeton.edu/perl/webwn

Congruency/Congruent-congruous: corresponding in character or kind
wordnetweb.princeton.edu/perl/webwn. In this thesis applied to gesture as intentional action

Consistency/Consistent - reproducible: capable of being reproduced, in this thesis of gesture

Conspecific: an organism belonging to the same species as another organism
wordnetweb.princeton.edu/perl/webwn

Corporeal ‘From Latin *corporeus*, from *corpus* (“body”). that which is material; tangible; physical’. Corporeality of gesture is fundamental to this study and relates directly to the notion of ‘Physicality and Tangibility of Interactions (PTI).

Deductive reasoning: inference, in which the conclusion is of no greater generality than the premises, i.e. is the process of deriving the consequences of what is assumed.

Ecology: 1. the environment as it relates to living organisms; "it changed the ecology of the island". 2. the branch of biology concerned with the relations between organisms and their environment. wordnetweb.princeton.edu/perl/webwn. Used specifically in this study to describe the interaction environment of child gesture and the system of Spatial Cognition.

Ecology of play: is sensitive to both the relationships of the players and the artefacts of play. Early work by McCune-Nicolich & Bruskin (1982) and others suggested the involvement and importance of temporal and structural components in play and developed a scheme for analysis of symbolic play based on Piagetian stages. *In this study these have been adapted for gesture but need not be used hierarchically.*

Embodied: ‘to embody (*third-person singular simple present embodies, present participle embodying, simple past and past participle embodied*). 1. (*transitive*) To represent in a physical form; to incarnate or personify.

‘Embodied entails the following: (1) cognition dependent upon the kinds of experience that come from having a body with sensorimotor capacities; and (2) individual sensorimotor capacities that are themselves embedded in a more encompassing biological and cultural context...sensory and motor processes, perception and action, are fundamentally inseparable in lived cognition, and not merely contingently linked as input/output pairs’ (Varela, 1999, p. 12).

Ephemeral; things (from Greek *εφήμερος* - *ephemerous*, literally "lasting only one day"^[1]) are transitory, existing only briefly. Typically the term is used to describe objects found in nature, although it can describe a wide range of things.’ Related in this thesis to the nature of embodied gesture and alludes to the developmental, dynamic and changing nature of gesture.

Episodic: occurring or appearing at usually irregular intervals; 2.a concept or idea not associated with any specific instance

Evaluate measure: evaluate or estimate the nature, quality, ability, extent, or significance of;
wordnetweb.princeton.edu/perl/webwn

Fidelity: is a notion that at its most abstract level implies a truthful connection to a source or sources.

Fuzzy logic: 1. A form or reasoning, derived from fuzzy set theory whereby a truth value need not be exactly zero (false) or one (true), but rather can be zero, one or a value in between. en.wiktionary.org/wiki/fuzzy_logic. 2. A way of reasoning that can cope with uncertain or partial information; characteristic of human thinking and some expert systems. www.wiley.co.uk/college/turban/glossary.html

Gestural Kineme: In this thesis derived from the concept of kineme - a group of movement associated with gesture action entity GAE that has the capacity to embody procedural, semantic and episodic knowledge.

Gesture: a form of non-verbal communication made with a part of the body, used instead of or in combination with verbal communication. The language of gesture allows individuals to express a variety of feelings and thoughts, from contempt and hostility to approval and affection. en.wikipedia.org/wiki/Gesture. 1. the set of simple instructions that combine to accomplish a task. 2. motion of hands or body to emphasize or help to express a thought or feeling. 3. the use of movements (especially of the hands) to communicate familiar or prearranged signals.

Gesticulate: show, express or direct through movement; something done as an indication of intention wordnet.princeton.edu/perl/webwn

Hermeneutics: (English pronunciation: /hɜːməˈnjuːtiks/) is the study of the principles of interpretation (from Greek *hermēneutikos* expert in interpretation, from *hermēneuein* to interpret, from *hermēneus* interpreter, of uncertain origin). Modern hermeneutics encompasses and includes verbal and nonverbal forms of communication. Interpretation theory: can be either the art of interpretation, or the theory and practice of interpretation. *Interpreted and used in this thesis to illustrate schematic relationships of Cognition in Action.*

Inductive reasoning: a form of reasoning that is part of the scientific method

Image schema: is a recurring structure within our cognitive processes which establishes patterns of understanding and reasoning en.wikipedia.org/wiki/Image_schema; a skeletal, abstract spatial relation considered to be basic to cognition. Dozens of image schemas have been identified, such as ABOVE, SUPPORT note: plural: schemata www.americanenviroics.com/methodology/glossary.shtml

Imagine: form a mental image of something; to envision or create something in one's mind; To believe in something created by one's own mind; to assume; to conjecture or guess; to use one's imagination; en.wiktionary.org/wiki/imagine.

Imaginary: 1. The psychological dimension of all images, conscious and/or unconscious. www.artgallery.nsw.gov.au/sub/spaceodysseys/glossary.html. 2. Extended in the discussions of this study to encompass actional features of gestural interaction. 3. An imaginary, or social imaginary is the set of values, institutions, laws and symbols common to a particular social group and the corresponding society. ...en.wikipedia.org/wiki/. 4. **Social imaginary:** a phrase coined by Charles Taylor, which refers to the horizon of understanding and the parameters for action, or what is unconsciously thinkable and doable in society. (168) faithfulpresence.com/index.php

Kineasthetic: 1. 'kinesthesia - the perception of body position and movement and muscular tensions etc., 2. kinesthesia - kinesthesis: the ability to feel movements of the limbs and body wordnet.princeton.edu/perl/webwn

Kinematic: (Greek κινεῖν, kinein, to move) is a branch of classical mechanics which describes the motion of objects without consideration of the circumstances leading to the motion. The other branch is dynamics, which studies the relationship between the motion of objects and its causes, en.wikipedia.org/wiki/Kinematic

Kinemes: In kinesics, a group of movements with an associated meaning, analogous to a phoneme in spoken language, en.wiktionary.org/wiki/kineme, see also Kinematics studies by Birdwhistell.

Ludic: derives from Latin ludus, "play." *Ludic* connotes anything that is "fun." '**Homo Ludens**, or "Man the Player," is a book written in 1938 by Dutch historian, cultural theorist and Professor Johan Huizinga. His 'Play Theory' suggests that play is primary to and necessary (though not sufficient) condition of the generation of culture. From the Greek παιδιά, pertaining to children's games

Metaphor: figure of speech in which the name of one object is replaced by another which is closely associated with it. So 'the turf' is a metonym for horse-racing, 'Westminster' is a metonym for the Houses of Parliament; 'Downing Street' is a metonym for the Prime-Minister. A closely related term is metonymy, in which a word with one original meaning is used to refer

to something else connected to it. *Extended in this thesis to the study of gesture and metonymic gestures.*

Microgenetic: when applied to methods of interaction is concerned with direct observation of process of change; has been applied in learning and cognitive development. In this study has been applied to the observation of gesture and gestural change in children.

Mime: act out without words but with gestures and bodily movements only; wordnetweb.princeton.edu/perl/webwn

Mimesis: (from Gr. *mimēsis*) is a critical and philosophical term that carries a wide range of meanings, which include: imitation, representation, mimicry and non-sensuous similarity, the act of resembling, the act of expression, and the presentation of the self. [.en.wikipedia.org/wiki/Mimesis](http://en.wikipedia.org/wiki/Mimesis)

Modularity: the design feature of being cleanly divisible into separate modules than can be moved, replaced, or adjusted more easily and independently than ... www.ideachg.com/montage/help/glossary.htm. In this thesis used to describe the ability of children to use this feature of the gestural system to effect change in their gestures.

module.http://en.wikipedia.org/wiki/Cognitive_semantics

Morphology: biology of animal or plant structure, en.wikipedia.org, *in this study morphology of gesture is related to corporeal structures and extended to cognitive constructs of gesture – Gesture Action Entity.*

Narrative: or story is a construct created in a suitable format (written, spoken, poetry, prose, images, song, theatre, or dance) that describes a sequence of fictional or non-fictional events. ... en.wikipedia.org/wiki/Narrative a narrative largely composed of loosely related episodes; refers to information relative to experiences, eg, stories and sequences of events, most often with a personal connection, chiron.valdosta.edu/whuitt/edpsyppt/Theory/info2.ppt

In this study the interpretation of gesture in narrative to reveal aspects of children's spatial cognition.

Nonverbal communication: is a dynamic process that engages the mind, body and society as intersubjective entities. Human create symbolic meanings for-and attach them to- the behaviours of self and others. They are influenced by the context of action and by master themes in society. In inner conversation with the self, or self-talk, humans propose and enact lines of action to fulfill the perceived demands of the situation, or the expectations of others.' Canfield, *Body, Identity and Interaction: Interpreting Nonverbal Communication Making sense of Nonverbal communication*, Chapter 3.

Nonverbal: 'non verbal communication is comprised of all of the messages other than words that people use in interaction (Hecht & Devito, 1990)' cited Canfield, *ibid*.

Ontogenetic: of or relating to the origin and development of individual organisms; "ontogenetic development" wordnetweb.princeton.edu/perl/webwn. Ontogeny (also ontogenesis or morphogenesis) (ontos present participle of 'to be', genesis 'creation') describes the origin and the development of ...en.wikipedia.org/wiki/Ontogenetic. In this study applied to the development of gesture in individuals.

Phylogenetic: of or relating to the evolutionary development of organisms; "phylogenetic development" wordnetweb.princeton.edu/perl/webwn. In this study applied to the development of gesture at societal and systems level.

Poiesis: in fact, is a play-function. In this thesis the idea of 'Mythopoiesis as myth-making' is considered as a structure to deal with both ambiguity and increase complexity of our interaction in veridical and imaginary worlds.

Polysemy: (from the Greek: πολυ-, *poly-*, "many" and σημα, *sēma*, "sign") is the capacity for a sign (e.g. a word, phrase, etc.) or signs to have multiple meanings (sememes), i.e. a large semantic field. This is a pivotal concept within social sciences, such as media studies and linguistics.

Praxis: "the generation of volitional movement patterns for the performance of a particular action, especially the ability to select, plan, organize, and initiate the motor pattern which is the foundation of praxis" (Ayres 1985).

Prosody: 1. the patterns of stress and intonation in a language; 2. in relation to gesture is more akin to prosody in music where the composer sets the text of a vocal composition in the assignment of syllables to the melody. Gesture the prosody relates to features of phasis (emphasis), temporality, rhythm and tone set to the corporeal 'text' of action. Cf. phonology of language the study of the sound system, cf. Melody (a succession of notes forming a distinctive sequence); in the case of gesture the succession is made up of gesture action entities.

Scripts: are the referential core of personal narratives (Labov and Waletzky, 1967) or the "canonical events" (Bruner, 1990) used as a basis for understanding new, unexpected elements. That is, scripts are predictive frames by which a culture interprets particular instances of behaviour associated with that script. Scripts do not require an evaluative component. *The scripts used in this thesis could be adapted to suit the individual or group need to tell/retell/enact a story. There was also the capacity to interact dynamically with the co-participants. In this study scripts were used in the stimulus condition of co-constructed narrative, e.g. the birthday party, cowboys come to town, day at the sea side, going out.*

Spatial: pertaining to or involving or having the nature of space; "the first dimension to concentrate on is the spatial one"; "spatial ability"; "spatial wordnet.princeton.edu/perl/webwn 2 Space is the extent within which matter is physically extended and objects and events have positions relative to one another . . .en.wikipedia.org/wiki/Spatial

Stories: expand on generalized scripts by incorporating particularistic (non-canonical) events, adding evaluative elements which reveal the narrator's viewpoint regarding these particulars. Thus stories will evaluate a script as good, bad, successful, tragic, surprising, and so on.

Symbolic function: is the capacity to represent the world as it is experienced and involves language, symbolic play, differed imitation and problem solving through a combination of mental actions and images, which constitute a system of meanings with symbolic function that enable diverse forms of representation', Piaget (1971).

Symmetry: in biology is the balanced distribution of duplicate body parts or shapes. The body plans of most multicellular organisms exhibit some form of symmetry, either radial symmetry or bilateral symmetry or "spherical symmetry". In my study used to refer to spatial execution of gesture typically bilateral.

Synergy: (from the Greek syn-ergos, συνεργός meaning working together) is the term used to describe a situation where different entities cooperate advantageously for a final outcome. Simply defined, it means that the whole is greater than the individual parts. en.wikipedia.org/wiki/Synergy. *In my thesis used to refer to synergy of gesture in terms of the notion of Gesture Action Entities.*

Themes: are sets of patterns. In this study themes are clusters of patterns that incorporate groups of gestural features, e.g. two major themes of corporality: dynamics and narrative together with strands that make up the themes.

Topology: (from the Greek τόπος, "place", and λόγος, "study") is a major area of mathematics concerned with spatial properties that are preserved under bicontinuous deformation; that is, stretching without either tearing or gluing. It emerged through the development of concepts from geometry and set theory, such as those of space, dimension, shape, transformation and others.'

Validate: give evidence for wordnetweb.princeton.edu/perl/webwn

Veridical: 'True. 1. Pertaining to an experience, perception, or interpretation that accurately represents reality; as opposed to unsubstantiated, illusory, or delusory. 'www.patana.ac.th/linklearn/Linklearn_interface/results/ll_check.asp