Abstract

Background: Children with speech sound disorders form a heterogeneous group who differ in terms of the severity of their condition, underlying cause, speech errors, involvement of other aspects of the linguistic system, and treatment response. To date, there is no universal and agreed upon classification system. Instead, a number of theoretically differing classification systems have been proposed based on either an aetiological (medical) approach, a descriptive-linguistic approach, or a processing approach.

Aims: The purpose of this article is to describe, and review the supporting evidence, and to provide a critical evaluation of the current childhood speech sound disorders classification systems.

Methods and Procedures: Descriptions of the major specific approaches to classification are reviewed and research papers supporting the reliability and validity of the systems are evaluated.

Main Contribution: Three specific paediatric speech sound disorder classification systems; the aetiologic-based Speech Disorders Classification System, the descriptive-linguistic Differential Diagnosis system, and the processing-based Psycholinguistic Framework are identified as potentially useful in classifying children with speech sound disorders into homogeneous subgroups. The Differential Diagnosis system has a growing body of empirical support from clinical population studies, across language error pattern studies, and treatment efficacy studies. The Speech Disorders Classification System is currently a research tool, with eight proposed subgroups. The Psycholinguistic Framework is a potential bridge to linking cause and surface level speech errors.

Conclusions and Implications: There is a need for a universally agreed upon classification system that is useful to clinicians and researchers. The resulting classification system needs to be robust, reliable and valid. A universal classification system would allow for improved tailoring of treatments to subgroups of SSD which may, in turn lead to improved treatment efficacy.

Keywords: childhood speech sound disorders, phonology, classification

What this paper adds

Children with speech sound disorders (SSD) comprise more than 70% of clinicians' caseloads and form an extremely heterogeneous group. One of the greatest difficulties facing the classification of such children is that there is no universal and agreed upon system for SSD. There is support for the division of speech disorder into those with a known aetiological cause versus unknown or "functional" speech disorders. However, how to further divide the resulting large, heterogeneous group of speech disorders of unknown origin remains controversial.

To date, there is no detailed comparative discussion and evaluation of alternative childhood SSD classification systems. This paper describes the classification systems, reviews existing empirical evidence, and evaluates the major classification systems against five criteria. This paper highlights the need for a clinically useful classification system that provides an explanation of SSD of unknown origin while directing clinicians towards the best treatment approaches to implement for the resulting SSD subgroups.

Introduction

Speech sound disorders (SSD) are the most common paediatric communication disorder, affecting between 10%-15% of preschoolers and 6% of school-aged children (ASHA, 2000; McLeod and Harrison, 2009). The minority of SSD cases are attributable to a known cause, such as a cognitive impairment, sensori-neural hearing loss, cleft lip and/or palate or cerebral palsy. For most children, the cause of their speech impairment is unknown (Broomfield & Dodd, 2004a; Shriberg & Kwiatowski, 1991). Children with an SSD of unknown origin are typically diagnosed between two and four years of age, and present with restricted speech sound systems without any apparent sensory, structural, neurological or psychological impairment (Gierut, 1998). Moreover, SSD of unknown origin can persist beyond the preschool years, placing some children at risk academically, socially, and vocationally (McCormack, McLeod, McAllister, & Harrison, 2009).

Over the last decade, researchers have increasingly acknowledged the heterogeneity of speech sound impairment (Tyler, 2010). There is now consensus that children with SSD do not form a homogeneous group (Baker, 2006; Bowen, 2009; Dodd, 1995; Grunwell, 1981; Shriberg, 1997; Stackhouse & Wells, 1997). Children with SSD differ in severity, underlying cause, speech error characteristics, involvement of other aspects of the linguistic system, response to treatment, and maintenance factors (Dodd, 2011). Interest in the classification of childhood SSD has grown since the 1990s, but to date, there is no universal and agreed upon system. The existing classification methods reflect the differing theoretical views of SSD, be it an aetiological (medical) approach, a descriptive-linguistic approach or a processing approach (Tyler, 2010). Figure 1 illustrates how the current classification systems can be conceptualized according to theoretical approach.

Figure 1 to appear about here

Classification

There is no single "natural and right classification system" (Cantwell and Baker, 1988, p.522) in the health sciences. Classification systems can, however, be objectively evaluated. Cantwell and Baker (1988) and Taylor (2011) proposed the following evaluation criteria: a) reliability – the degree to which all clinicians using the system would arrive at the same diagnosis for a given client; b) validity – the extent to which a system measures what it purports to measure and includes face (clinicians' intuition), descriptive (uniqueness of categories), predictive (ability to predict outcome) and construct (relationship to theory) validity; c) coverage – the extent to which the system is able to accurately differentially diagnose all presenting individuals into distinct subgroups while ensuring sensitivity (identifying true positives), specificity (identifying true negatives), and reducing incorrect diagnoses (false positives and false negatives), and d) feasibility – the extent to which a classification system can be successfully used by the professionals for whom it was designed. This paper presents a description and review of the evidence, and a critical evaluation using the criteria listed above, for three major specific childhood SSD classification systems, namely Shriberg's (2010) Speech Disorders Classification System, Dodd's (2005) Differential Diagnosis, and Stackhouse and Wells (1997) Psycholinguistic Framework.

Aetiological (medical) approach

Aetiologically-based classification systems are a-theoretical and start from a position of pathology rather than normality. The central assumption of the aetiological approach is that an underlying clinical entity or medical condition is responsible for a child's presenting SSD. There are two types of aetiological based classification systems: broad-based, which provide a classification system for more than communication disorders, such as the Diagnostic and

Statistical Manual (DSM-IV-TR) (American Psychiatric Association, 2000); and the International Classification of Diseases and Related Health Problems (ICD-10) (WHO, 2007); and SSD-specific classification systems.

Broad-based classification systems

Currently there are three broad-based aetiologically-based systems available for classifying childhood SSD. These are the Diagnostic and Statistical Manual (DSM-IV)(DSM-IV-TR) (2000), the World Health Organization's International Classification of Diseases (ICD-10) (1993), and the International Classification of Functioning, Disability and Health (ICF)(WHO, 2001) including the subsequent Children and Youth Version (2007). The DSM-IV and the ICD-10 are the most clinically utilized classification systems; mainly due to familiarity of the classification systems amongst health professionals and for insurance billing purposes (McCauley, 2004). Table 1 provides a summary of the DSM-IV TR and ICD-10 SSD classification codes. The ICF-CY offers an alternative classification for SSD. The ICF recognizes five domains, namely Body Structure, Body Function, Activities and Participation, Environmental Factors, and Personal Factors. According to the ICF, if there is a known sensory, neurological, or craniofacial impairment (for example hearing loss, cerebral palsy, cleft lip and/or palate), the speech impairment if classified at the Body Structure level. If there is no known cause, the speech impairment is classified at the Body Function level.

Table 1 about here

These broad-based classification systems have played an important role in establishing a framework for categorizing childhood SSD by providing a common reference frame for clinicians. Most importantly, the coding systems of the DSM-IV and ICD-10 have ensured

clinicians differentiate between SSD only, SSD and language disorders, and SSD and other pervasive disorders. The ICF-CY has encouraged (and continues to encourage) the pursuit of a better understanding of the short and long term effects of childhood SSD on education, employment, social development and quality of life.

Unfortunately the DSM-IV-R, the ICD-10, and the ICF-CY are inadequate classification systems for differentially diagnosing childhood SSD. The three classification systems are too broad in their subgroup definitions resulting in children with SSD of unknown origin ending up in one of two subgroups; either speech sound production problems ('articulation' errors) and cognitive-linguistic based problems (phonological errors) subgroups, or known versus unknown aetiology subgroups. Specific childhood SSD classification systems have been developed to address this heterogeneous subgroup problem.

A Brief History of Specific Aetiological Classification Systems

The first childhood SSD classification systems were strongly influenced by the medical approach (Bowen, 2009). The early classification systems focused on delineating three causes of SSD: a) a known cause; b) a putative or supposed cause and an c) unknown cause. An early example of an aetiological classification system is T. Ingram's (1959) classification system. Ingram's (1959) six speech disorder subgroups appear in Table 2.

Table 2 to appear about here

Recently, Ruscello (2008) described a four-subgroup aetiological SSD-specific classification system. A key feature of this classification system is the division of children with SSD into those with a known-versus-unknown aetiological basis for speech impairment. Children with

SSD are grouped according to the presence or absence of at least one structural, sensory or neurophysiological factor. An unknown category is provided as a default category. Ruscello's (2008) subgroups are presented in Table 3.

Table 3 to appear about here

A significant weakness with aetiological classification systems is the failure to subdivide the large and heterogeneous SSD group of unknown origin. The lack of true differentiation reduces the explanatory power and clinical utility of the aetiological classification system to account for SSD and aid the management of children with speech impairment. Shriberg and colleagues attempt to address these issues with the proposed Speech Disorders Classification System.

Speech Disorders Classification System (SDCS): Description

The Speech Disorders Classification System (SDCS) was developed to address the issue of how to classify children with SSD of *unknown* origin. The SDCS has been developed over the last thirty years, is based on the data of several hundred subjects with SSD of unknown origin and has evolved from five subgroups (Shriberg, 1994) to seven subgroups (Shriberg, 2006), to the current eight subgroups of SSD (Shriberg, Fourakis, Hall, Karlsson, et.al., 2010a). The SDCS's underpinning premise is that an unvarying relationship exists between an identifiable genetic anomaly and a specific type of speech behaviour. Shriberg (2010) asserts that a genetic variation, (in conjunction with possible environmental factors), is the primary origin of each aetiologic subgroups, except for residual speech errors which are caused by environmental factors alone. Table 4 provides a summary of the eight SSD of unknown origin subgroups.

Table 4 to appear about here

SDCS Evidence

Over the last decade, Shriberg and his colleagues have attempted to identify diagnostic markers, or distinct error patterns which distinguish the SDCS proposed subgroups. Atypical sound errors (i.e. those that fall outside the "natural" processes of assimilation, cluster reduction, final consonant deletion, liquid simplification, palatal fronting, stopping, velar fronting and unstressed syllable deletion) have been investigated as potential diagnostic markers (Shriberg, Kent, Karlsson, McSweeeny, et.al., 2003). In addition, a range of speech indices (including competence, precision, and stability) have been developed from the calculation of various measures based on a large database (Shriberg, Fourakis, Hall, Karlsson, et al., 2010a). Finally, case history risk factors have also been examined, to determine potential subgroup differences. According to Shriberg (2010), there is a preliminary pattern of risk factors and diagnostic markers that differentiate the groups but "few of the markers have demonstrated sufficient diagnostic accuracy" (p.26). Further research is required to provide sensitive and specific diagnostic markers if the subgroups are to be empirically validated. Table 5 provides a summary of current specific subgroup patterns.

Table 5 to appear about here

SDCS Evaluation

The SDCS has attracted support in the USA and Australia since its inception. The support for the SDCS is due in part to its perceived high face validity. The major divisions of speech delay, motor speech disorder and residual speech errors seem to resonate with clinicians who informally recognize these subgroups and who favor a medical approach to explaining the

causes of SSD of unknown origin. A detailed evaluation of the SDCS raises a number of issues, however, with the overall validity, coverage and clinical feasibility.

A significant difficulty with the SDCS is the uniqueness of each subgroup category. The lack of empirically supported sensitive and specific diagnostic markers compromises the descriptive validity of the eight subgroups, particularly the three speech delay subgroups. Shriberg (2010) has suggested that the speech delay subgroups may be overlapping and not distinct subgroups. This is a significant concern as these groups (according to the SDCS) comprise approximately 98% of the SSD of unknown origin cases. Collapsing the speech delay subgroups would result in only 2% of the SSD of unknown cases being differentially diagnosed from the larger, presumably heterogeneous group.

A clinically useful classification should allow clinicians to predict the severity, nature, course and likely responses to intervention. A significant problem with the aetiological SDCS is that the diagnostic labels provide little information about the nature and severity of a child's speech difficulties, or the type of treatment indicated. Shriberg has provided some preliminary "clues' as to what direction intervention should take based on the explanatory processes involved in each subgroup; however, to date no research has been conducted that matches diagnostic label to specific interventions to determine if there is a differentiated response to treatment. This type of research would provide additional support for the predictive validity of the SDCS.

Establishing single causal factors to account for the SSD of unknown origin subgroups is a critical problem with the SDCS (McCauley, 2004; Tyler, 2010). There is little support for the theoretical construct that a one-to-one relationship exists between a genetic anomaly and a

subgroup of SSD. Most researchers view multiple and complex genetic variants and environmental factors, in addition to maintenance factors, as causing speech (and language) impairments (Newbury and Monaco, 2010). How the SDCS' theoretical underpinnings stand up over time will depend on future genetic research. Practically, the therapeutic value of genetic subgrouping will be irrelevant if it does not alter clinical treatment. To date, there is only speculative information about how gene therapy techniques may influence the treatment of childhood SSD (Lewis, 2010).

The SDCS' coverage is also questionable because clinical intuition suggests that some children might be unclassifiable under the SDSC. For instance, how would a child presenting with no history of family speech and language difficulties, OME, or psychosocial issues, intact motor speech skills but atypical speech sound errors (initial consonant deletion, backing of stops and devoicing) be classified? Fox, Howard and Dodd's (2002) study investigated the relationship between risk factors (such as history of hearing loss, family history) and speech disorders. The investigators were unable to classify more than half of their subjects using Shriberg's 1994 version of the SDCS. Individuals who could not be classified presented with more than one risk factor or with none of the risk factors. Further evidence of the SDCS' exhaustiveness is required.

The feasibility of the current SDCS is difficult to judge as it is a research tool and is not yet intended for clinical use. However, the SDCS' dependency on narrow phonetic transcription, the use of complex formulae to ascertain many of the codings, and the necessary time to complete each assessment would make the current SDCS an unwieldy clinical classification tool. To become clinically useful, accessible analysis software will be required at the very least.

Finally, Shriberg et al (2010b) have reported high interjudge and intrajudge agreement for coding diagnostic markers. How well clinicians would reach the same diagnosis for each child with SSD using the SDCS is unknown.

Descriptive-linguistic Approach

The descriptive-linguistic approach to classification involves describing children's speech sound disorders according to the error patterns exhibited (Kamhi, 1989). The approach is developmental and relies on identifying and describing how a child's speech differs from that of a child at the same age with typical development.

A Brief History of Descriptive-Linguistic Classification Systems

The emergence of the descriptive-linguistic approach in the 1960s/1970s was revolutionary and fundamentally changed the theoretical framework for assessing and diagnosing children with SSD (Grunwell, 1997): rather than children with unintelligible speech being classified as 'multiple misarticulators' with numerous individual sound errors, children were seen as having sound class problems. Order was found in disorder (Grunwell, 1997), and a shift in conceptualizing speech impairments from occurring at the 'mouth' to occurring in the 'mind' began. Importantly, distinctions were made between normal, delayed and deviant speech development. The delayed-deviant dichotomy is apparent in Grunwell's (1985) five category classification system for children with phonological disorders. See Table 6.

Table 6 to appear about here

Ingram (1997) also postulated a speculative and tentative descriptive-linguistic typology of phonological impairment, based on single subject phonological analyses. Ingram proposed four types of phonological impairment which are summarized in Table 7.

Table 7 to appear about here

These descriptive-linguistic classification systems were the antithesis of the aetiological approach which was still highly influential on clinical practice throughout the 1960s, 1970s and beyond (Bowen, 2009). A major criticism of descriptive-linguistic classification systems is that emphasis is placed solely on the speech output of the children, obscuring the influence of other non-language factors such as cognitive functioning, social and environmental factors (Kamhi, 1989). Another frequently cited criticism is that clinicians use phonological process terminology as explanations rather than the descriptions they were intended to be (Locke, 1983). Finally, in terms of classifying all children with SSD, the classification models do not explicitly recognize children with purely articulation (phonetic) impairments or motor planning/programming-based speech impairments resulting in an overlap of categories and diminished subgroup uniqueness. Dodd's (1995; 2005) differential diagnosis of SSD model addresses these issues.

Differential Diagnosis System Description

Dodd (1995; 2005) proposed a classification model anchored in the descriptive linguistic approach that consists of five subgroups of SSD. The central premise of Dodd's classification system is that subgroups can be identified by surface level pattern errors that reflect underlying subgroup-specific processing deficits. Dodd developed the Differential Diagnosis system from a theoretical basis, using broadly recognized subgroups, namely "phonological delay" (Leonard, 1973; Grunwell, 1982; Ingram, 1976), "deviant" development (Ingram, 1976; Grunwell, 1985; Leahy and Dodd, 1987), and inconsistent error patterns (Grunwell, 1985), combined with her own clinical experience. Table 8 provides a summary of the proposed subgroups.

Table 8 to appear about here

Differential Diagnosis System Evidence

Over the last two decades, Dodd and colleagues have provided a range of empirical evidence to support the validity and clinical utility of the classification model (Dodd, 2011). Research has focused on demonstrating that: a) all children with SSD of unknown origin can be classified by surface error patterns into the five proposed subgroups; b) the subgroups have distinct deficits or 'profiles' that underlie children's speech difficulties; c) matching subgroups to intervention techniques results in increased treatment efficacy; and d) that non-English speaking children with SSD of unknown origin can be classified into the same proposed subgroups, and with similar prevalence across a range of languages. Each evidence type is reviewed briefly below.

Differential Diagnosis System classification by surface error patterns: Two studies investigated the potential of assigning children with SSD to Dodd's five subgroups based on analysis of surface error patterns. Using identical group allocation rules, Dodd, Leahy and Hambly (1989) and Broomfield and Dodd (2004b) assigned a combined total of 246 children whose primary difficulty was SSD of unknown origin into articulation disorder, phonological delay, consistent atypical phonological disorder or inconsistent phonological disorder subgroups based on error pattern analysis. The two studies reported comparable incidence percentages. No children were diagnosed with childhood apraxia of speech (CAS).

Differential Diagnosis System underlying subgroup processing profiles: Dodd and colleagues investigated the linguistic knowledge (phonological legality, phonological awareness,); cognitive (executive function), output processing (phonological planning, phonetic planning) and motor-execution skills of children within the four major subgroups (i.e. excluding the

CAS subgroup), to provide subgroup processing profiles. These studies compared two, three or four subgroups, and typically developing control groups.

Dodd, Leahy and Hambly (1989) and Holm, Farrier and Dodd (2008) findings suggested differences in phonological awareness skills between the proposed subgroups. Results indicated that children with inconsistent phonological disorder have poor syllable segmentation skills, preference for phonologically legal nonsense words, and intact alliteration awareness. Children with consistent atypical phonological disorder have no preference for legal or illegal nonsense words, and the poorest rhyme and alliteration awareness of the subgroups. Dodd and colleagues argued that children with inconsistent phonological disorder have a deficit in phonological assembly while children with atypical phonological disorder have difficulties at the cognitive-linguistic level, possibly with linguistic rule abstraction. Further studies by Dodd and Macintosh (2008), Crosbie, Holm and Dodd (2009) and Dodd (2011) demonstrated that children with consistent atypical phonological disorder perform less well than typically developing, phonologically delayed and inconsistent phonological disordered children on tasks of rule abstraction and cognitive flexibility. Finally, Bradford and Dodd (1994) demonstrated that it was possible to differentiate children with inconsistent phonological disorder from other children with SSD using motor tasks.

It is our interpretation of the data reported herein, that this is support for the distinct underlying deficits hypothesis of the proposed subgroups. However, a number of methodological issues need to be considered. First, each study employed a separate group of subjects and no study investigated the phonological awareness skills, rule abstraction and flexibility, and motor skills in the same groups of children. It is unclear if similar results

would be replicated if the same children were measured on all profiling tasks. Second, vocabulary age was not taken into account when comparing the SSD subgroups. Vocabulary size has been implicated in contributing to the variance in phonological awareness task performance (Preston and Edwards, 2010). Dodd's lack of information on vocabulary age and expressive language skills makes it impossible to discount the role vocabulary and language differences may have had on differing task performance, especially phonological awareness tasks, between the proposed subgroups. Third, Dodd's classification system critically depends on the multisyllabic word inconsistency task which involves repeating the same set of 25 words over three separate trials. The validity of this task has not been determined and other consistency measures, such as those described by Preston and Koenig (2011) are under investigation. Fourth, Dodd, Lahey and Hambly (1989) employed a self-constructed legality judgment task. No validity data is available for this task. Replication, using an alternative legality judgment task, such as the legal versus illegal words task (Stackhouse, Vance, Pascoe and Wells, 2007) would make a useful comparison. Finally, Dodd's profile studies would benefit from replicated studies, conducted by different research groups, using larger sample sizes.

Differential Diagnosis System intervention studies: Dodd and Bradford (2000) described three case studies of children classified with consistent atypical phonological disorder who received three therapy treatments (phonological contrast; core vocabulary and PROMPT). Crosbie, Holm and Dodd (2005), used a multiple baseline design with alternating treatment to compare the effectiveness of phonological contrast therapy and core vocabulary therapy with 18 children. Results of both studies indicated differential responses to treatment with children with inconsistent phonological disorder responding best to core vocabulary treatment, and children with consistent atypical phonological disorder responding best to

phonological contrast therapy. The results should be treated cautiously, however, due to small sample sizes and the possible cumulative effects of treatment (Dodd and Bradford, 2000).

Broomfield and Dodd (2011) conducted a randomized control trial to measure the effectiveness of speech and language therapy for children with speech/language impairment. Children with articulation disorder and/or phonological impairment were included in the study. Recognized treatments such as Metaphon (Howell and Dean, 1991) and Core Vocabulary (Holm, Crosbie and Dodd, 2005) were matched to individual participants based on age and diagnostic profile. Results showed that children who received targeted interventions showed significant improvement over children who received no intervention. These preliminary findings suggest that there may be merit in further investigating the matching of specific treatments to SSD subgroups.

Differential Diagnosis System cross-language studies

The concept of universality among children with different linguistic backgrounds was studied by Dodd and her associates. So and Dodd (1994) described the phonological systems of 17 monolingual Cantonese speaking children with SSD aged between 3 years 6 months and 6 years 4 months. Results indicated that all the children could be classified into the articulation disorder, phonological delay, consistent deviant disorder or inconsistent disorder subgroups. Zhu Hua and Dodd (2000) classified 33 Mandarin speakers with SSD of unknown origin. Again, all children were classified into one of the four proposed subgroups. In a larger scale study, Fox and Dodd (2001) classified 100 German speaking children with SSD into Dodd's (1995) proposed subgroups. The combined results reveal that all the children could be classified and similar subgroup prevalence prevailed.

The cross-language findings support using Dodd's classification system regardless of the phonological system being learnt. Further studies investigating the cognitive-linguistic profiles of children with SSDs who speak languages other than English are needed to determine if the same proposed speech-processing deficits are identifiable in each of the subgroups. Such findings would provide compelling support for Dodd's classification system.

Differential Diagnosis System Evaluation

Dodd's classification system is a potentially clinically useful classification tool. The system is theory driven, incorporating theories of normal (Macken and Ferguson, 1983) and abnormal linguistic development (Grunwell, 1985) along with more recent psycholinguistic theories (Stackhouse and Wells, 1997). The theoretical basis of Dodd's Differential Diagnosis provides strong construct validity. The classification system also seems to have high predictive validity. For instance, Dodd has constructed speech sound profiles, which summarize the major features of the subgroups, the impact of speech intelligibility, and recommendations for treatment. Coverage is also adequate given that to date, no child has been left unclassified by the system.

The categorization of children with SSD using Dodd's system has become more feasible with the publication of the Diagnostic Evaluation of Articulation and Phonology (DEAP) (Dodd, Hua, Crosbie, Holm, and Ozanne, (2002), which is a standardized test based on Dodd's theoretical model. The test appears time efficient with the inclusion of a screening task which directs the assessment and differential diagnosis process. Moreover, the DEAP is readily accessible to clinicians in Western countries. The clinical uptake of the DEAP

provides evidence of some face validity (Joffe and Pring, 2008; Pring, personal correspondence, 2012). Investigations quantifying the adoption of Dodd's Differential Diagnosis classification system, as opposed to the use of individual subtests, are needed to establish face validity. Moreover, evidence regarding the reliability of diagnosis between clinicians is also required. Presently evidence is cited about test-retest reliability and inter-rater reliability, however, how well all clinicians using the DEAP arrive at the same diagnosis is unknown.

Dodd and colleagues' body of research provides the groundwork for establishing the validity of the Differential Diagnosis classification system. More evidence regarding the sensitivity and specificity of the DEAP is required. Further investigations are needed into the underlying cognitive-linguistic profiles of the proposed subgroups, of both English and non-English speakers, given that a central tenet of the classification system is that speech errors are symptomatic of underlying subgroup specific processing deficits. Finally, further empirical evidence supporting the division between inconsistent phonological disorder and childhood apraxia of speech is needed, with emphasis on establishing the validity of the DEAP speech consistency task.

Processing approaches

The psycholinguistic processing approach employs models of speech processing in children to explain "how" speech impairment arises. Kamhi (1989) described the psycholinguistic processing approach as a bridge between aetiological classification and linguistic descriptions. The central premise of the psycholinguistic processing approach is that children's speech impairments are due to a breakdown in the speech processing chain. This breakdown may occur at one or more of the following levels: a) peripheral hearing; b)

auditory discrimination of phonemic distinctions; c) storing words accurately; d) planning speech output; and/or e) executing speech. Psycholinguistic speech-processing models vary considerably in their complexity; however the application to individuals is the same: a series of hypotheses are developed and systematically tested to find where the breakdown(s) is occurring. Thus, the psycholinguistic speech processing approach can be used with any child regardless of whether or not there is a known aetiological cause (e.g. cerebral palsy, Down syndrome, hearing loss, SSD of unknown origin).

A Brief History of Processing Approaches

Two broad types of psycholinguistic approaches have been proposed. The first type is pictures of boxes and arrows, with the boxes representing levels of processing and the arrows representing processing routes. Box and arrow models differ greatly in complexity with some models (Smith, 1973) having only one or two boxes between input and output, and others having multiple boxes and real-time and time-free processing arrows (Hewlett, 1990). Examples of early box and arrow models are Winitz (1975), Menn (1978), Grundy (1989), and Hewlitt (1990).

Winitz (1975) described five levels of breakdown in the speech-processing chain: a) auditory input (hearing, discrimination or impoverished environment), b) phonological (impairment in attention, reasoning, memory or motivation leading to problem abstracting phonological rules), c) systematic phonetic (difficulty with planning speech output), d) articulatory planning (difficulty with sequencing speech sounds) and e) motor execution (impairment of motor execution due to neurological dysfunction). Winitz' model was promising because it provided categories of SSD. Unfortunately, the majority of children with SSD of unknown origin fall into the phonological subgroup. Consequently, his classification is not

sufficiently sensitive to discriminate between the groups of children most in need of classification, i.e. children with cognitive-linguistic based SSD.

Grundy (1989) proposed a simple input, storage and output model that divided SSD of unknown origin into an articulatory (impairment of phonetic production) and a phonological component (a linguistic disorder). According to Grundy (1989), phonological disorder arises from "the productive, or the perceptive, or the organizational mechanisms of speech" (p.257). This account is inadequate in terms of both classification of SSD and as a description of breakdown.

The second type of psycholinguistic approach is the connectionist models. Connectionist models are computer-driven and are currently not clinically usefully due to the time-intense nature of designing and running models with children's speech data (Baker, Croot, McLeod, and Paul, 2001) For a detailed description and discussion of connectionist models see the tutorial by Baker, Croot, McLeod and Paul (2001).

Stackhouse and Wells Psycholinguistic Framework Description

The Stackhouse and Wells' (1997) Psycholinguistic Framework is a box and arrow model which links speech processing theory and clinical practice. The Stackhouse and Wells (1997) framework is driven by three central tenets. First, typical speech development depends on a normally functioning speech processing system. Second, SSD result from a breakdown at one or more points in the speech processing system, and third, SSD can be remediated by targeting the faults in the speech processing system. The framework is a developmental, linear model that includes input, representation and output abilities that purportedly underlie

speech production, and five phases of development; the a) prelexical phase; b) whole word phase; c) systematic simplification phase; d) assembly phase; and e) metaphonological phase.

The Stackhouse and Wells framework (1997) was not intended to be a classification system; rather it was developed to provide individual profiles of the underlying speech processing abilities and deficits of children with and without speech and/or reading impairments. The inclusion of developmental phases lends the approach to describing a child with an SSD by the phase level at which he/she is habituated. A child could receive a number of descriptions over time if he/she was to habituate at more than one level (Stackhouse and Wells, 1997).

Psycholinguistic Framework Evidence

Numerous studies have investigated the key hypotheses that a) children with SSD have specific deficits at one or more points in the speech processing chain which differentiates them from typically developing children, and b) targeting deficits leads to improvements in speech output.

Specific deficits: Stackhouse, Nathan, Goulandris and Snowling (2002), conducted a longitudinal study of 47 children with SSD of unknown origin (boys = 31; girls = 16). The study compared children with SSD of unknown origin with typically developing children to test whether children with SSD have a deficit at one or more points in the speech processing chain. Each child with SSD was matched on the basis of chronological age, gender and non-verbal IQ to a typically developing child from the same pool of nurseries/schools. Each pair was assessed on a range of speech processing tasks (picture naming; real word repetition; non-word repetition; speech rate; mispronunciation detection; auditory discrimination of words, non-words, same/different ; rhyme production; rhyme detection) and non-verbal-IQ,

language, phonological awareness, and literacy tests at three age points (t1 = 4yrs, t2 = 5yrs and t3 = 6yrs).

Typically developing children performed significantly better than the children with SSD on the majority of speech, language and phonological awareness measures. The typically developing children also performed better on literacy tasks at t2 and t3. The authors reported that the children with SSD showed different profiles in performance across tasks, with some children showing age-appropriate skills on some tasks. The findings demonstrated the heterogeneity of SSD and the possibility of processing strength and weakness profiles.

Numerous profiles of children with SSD have been published which have demonstrated how children given the same diagnostic label can perform markedly different on speech processing tasks (Stackhouse, Pascoe and Gardner, 2006; Stackhouse and Snowling 1992; Stackhouse and Wells, 1997). Stackhouse, Vance, Pascoe and Wells (2007) provide the speech processing profiles of two 4 year old children diagnosed with "phonological delay". Zara was found to have specific speech output difficulties (i.e. difficulties with naming, word and nonword repetition and self-monitoring) with intact input skills, while Tom was found to have pervasive input and output difficulties, including discrimination, naming and word and nonword repetition.

Psycholinguistic Framework treatment case studies: Numerous quasi-experimental studies (Bryan and Howard, 1992; Pascoe, Stackhouse, and Wells, 2005, 2006; Waters, Hawkes, and Burnett, 1998) and nonexperimental case studies, (Corrin, 2001a, 2001b; Nathan and Simpson, 2001; Nathan, Stackhouse, Goulandris, and Snowling, 2004; Rees, 2008; Stackhouse and Wells, 1993, 1997; Stackhouse, Pascoe, and Gardner, 2006; Vance, 1997;

Waters, 2001) have investigated the effectiveness of tailoring intervention to match strength and/or deficit areas to improve speech output and/or literacy skills. The Katy single subject study is an example of tailoring intervention (Pascoe, Stackhouse, and Wells, 2005). Katy presented at six years, five months with mild ataxic cerebral palsy, persistent unintelligible speech and a long history of speech therapy. An initial assessment revealed a PCC of 22%, PVC of 74.1%, PPC of 41.9% and a connected speech PCC of 25%. Her speech consisted predominately of CV and CVCV syllable structures. Psycholinguistic assessment revealed that Katy had difficulty with retrieving stored motor patterns, creation of on-line motor programs, and motor planning. Katy received 30 hours of treatment which involved three treatment phases: a) targeting a specific set of single words; b) targeting a wide range of single words; and c) targeting words in connected speech (using controlled sentences). The post-intervention assessment revealed an: a) expansion of word-final phonetic inventory; b) improved production of final consonants in single words; c) increase in PCC; and d) following specific targeting of connected speech, a decrease in final consonant deletion in connected speech. Pascoe, Stackhouse and Wells (2006) present a further five detailed tailored intervention case studies.

Combined, the longitudinal, single case design and case studies provide support for the Stackhouse and Well's psycholinguistic framework (1997). Specifically the studies highlight the complex nature of SSD, including how children with the same (aetiological) diagnosis can present with differing breakdown point(s) in the speech processing chain; and how breakdowns can be mapped to reflect habituation at varying levels of proposed speech development. Additional and stronger rated empirical evidence (i.e., single case design rather than case studies) is needed.

Psycholinguistic Framework Evaluation

The Stackhouse and Wells (1997) framework allows for the categorization of children with SSD of unknown origin into profiles using a psycholinguistic approach. The framework has high construct validity. The framework is based on years of psycholinguistic and cognitive neuropsychological research (Stackhouse and Wells, 1997), including Waterson (1987) and Hewlitt (1990). The framework does, however, have some theoretical shortcomings. First, breakdown hypotheses are restricted to input and output mechanisms. It is possible that deficits are arising from a more central level such as the learning of phonological constraints (Dodd, 2005). Second, deficits in the speech processing model are treated as cause of the SSD. It is possible that the speech processing difficulties are a consequence or co-morbid symptom of another underlying deficit, for example Zelazo and Muller (2002) and Dodd (2011) argue that higher order executive function deficits (e.g. deficits in rule abstraction, flexibility) can negatively impact on the speech processing chain.

The Stackhouse and Wells (1997) framework is an inclusive diagnostic system designed to be used with all children with SSD. The framework is sensitive to differences in speech processing between children with and without SSD. Stackhouse and Wells argue that all children with SSD should be regarded as having a unique pattern of strengths and weaknesses. The uniqueness position impacts negatively on the predictive validity of the framework. If every child is regarded as unique, it becomes difficult to predict how a child will improve over time or respond to treatment.

The Stackhouse and Wells (1997) framework has high face validity, especially as the assessment procedures encourage an holistic approach, incorporating medical, linguistic, developmental, educational and psycholinguistic perspectives. Moreover, the framework's

developmental phases (i.e. prelexical, whole word, systemic simplification, assembly, and metaphonological) are clinically intuitive. The clinical feasibility of the framework is potentially high, once therapists overcome initial anxieties (Gardner, 2009), and become familiar with psycholinguistic oriented tasks such as those detailed in the "Compendium of Auditory and Speech Tasks" (Stackhouse, Vance, Pascoe & Wells, 2007). Finally, potential variations in diagnosis between clinicians seem possible, leading to reduced reliability of the Psycholinguistic Framework.

Discussion

Summary of Classification Systems

Three classification systems were critiqued in detail in this paper; Shriberg's (2010) Speech Disorders Classification System, Dodd's (1995; 2005) Differential Diagnosis System, and Stackhouse and Wells (1997) Psycholinguistic Framework. An evaluation summary appears in Table 9.

Table 9 about here

The SDCS is still primarily a research tool driven by a search for genetic factors associated with speech disorders. The value of the theoretical underpinnings of the SDCS may not be fully apparent until the repercussions of genetic research impact upon speech pathology, sometime in the future. If researchers are able to identify specific markers that can be readily employed by clinicians to classify children with SSD of unknown origin into the eight putative SDCS subgroups, the classification system would become clinically useful. Further validation is required before the SDCS is used as a clinical tool.

Dodd's Differential Diagnosis is a clinically feasible, inclusive classification system that divides children with SSD of unknown origin into discrete subgroups. More research is needed to profile the cognitive-linguistic difference between the subgroups. The validity of Dodd's classification system would be strengthened by replication studies, conducted by different research groups.

Stackhouse and Well's (1997) Psycholinguistic Framework demonstrates the complexity of SSD, and illuminates the speech processing differences between children with the same purported aetiology. Perhaps when more data is collected, a trend in strengths and weakness between and within the phases will emerge.

Comparing and Contrasting the Classification Systems

Superficially, the three classifications systems appear markedly different, yet a close inspection reveals numerous similarities. All three classification systems recognize three common subgroups: a) an articulation-based subgroup; b) a motor planning/programming subgroup; and c) a phonological subgroup characterized primarily by simplification processes. Moreover, the SDCS and the Stackhouse and Wells framework recognize a subgroup with auditory-based input deficits, while the Differential Diagnosis system and the Stackhouse and Wells Framework recognize children with inconsistency but no oro-motor difficulties. How to differentiate the large phonological-based subgroup still remains controversial. Further evidence is required to determine if there are qualitative differences between children with phonological delay, consistent typical and consistent atypical phonological errors as proposed by the Differential Diagnosis classification system, or whether the SDCS speech-delay genetic, otitis media and psychosocial subgroups are valid.

Alternatively, further research using the Stackhouse and Wells framework may find a trend in strengths and weakness amongst children.

All three classification systems are driven to identify the basis of SSD of unknown origin. In each classification system, underlying cognitive-linguistic processes are identified as playing a role in SSD. The difference is that the SDCS proposes that genetic variations lead to cognitive-linguistic changes for some of the subgroups, while the Differential Diagnosis system and the Stackhouse and Wells framework propose that cognitive-linguistic deficits are what differentiate children with SSD.

The three classification systems also share the same dual purposes: to a) improve the efficacy of treatment for children with SSD of unknown origin, and b) allow for future research into the basis of SSD. The SDCS is currently more research focused with emphasis on identifying genetic variations related to speech and language impairments rather than treatment focused. Conversely, the Differential Diagnosis and Stackhouse and Wells framework are more treatment focused and regard the aim of diagnosis and classification as identifying processing strengths and weaknesses which can be exploited in intervention, and used to predict later speech and literacy difficulties. This fundamental difference in focus has influenced the types of empirical studies conducted to date.

Finally, all three classification systems recognize the need for a broad-based assessment for children with SSD which takes into account the strengths of the medical, linguistic, psycholinguistic, psychological and educational perspectives. The difference rests in how much weighting each classification system gives to potential diagnostic elements such as, underlying medical condition; family history; types of sound errors; speech processing; and

importance of memory, and higher executive functions. For example, the SDCS and the Differential Diagnosis system both give substantial weight to the importance of the nature of the speech sound errors as indicators of subgroup while the Stackhouse and Wells framework proposes that sound error patterns are not indicative of a specific breakdown, and can arise from any point(s) in the speech processing chain.

The future

There is universal agreement that children with SSD of unknown origin are heterogeneous. An agreed upon classification system is needed to facilitate communication between professionals and to allow further testing of diagnostic and treatment hypotheses (Taylor, 2011). The challenge ahead is to construct an inclusive, universally agreed upon classification system that meets the needs of clinicians and researchers. At a minimum, the resulting classification system will need to –

a) classify all children with SSD of unknown origin into discrete subgroups;
b) have accurate, specific and sensitive diagnostic markers;
c) have universal applicability;
d) improve clinical management by directing treatment differentiation;
e) be feasibly implemented in the clinical setting; and
f) contribute towards an explanation of childhood SSD.

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References

AMERICAN PSYCHIATRIC ASSOCIATION, 2000, *Diagnostic and statistical manual of mental disorders – Fourth edition, Text revision (DSM-IV-TR).* (Washington, DC: American Psychiatric Publishing).

AMERICAN SPEECH-LANGUAGE-HEARING ASSOCIATION, 2000, *Communication facts.* (Rockville, MD).

BAKER, E., 2006, Management of speech impairment in children: The journey so far and the road ahead. *Advances in Speech-Language Pathology,* **8**(3), 156-163.

BAKER, E., CROOT, K., MCLEOD, S., and PAUL, R., 2001, Tutorial paper: Psycholinguistic models of speech development and their application to clinical practice. *Journal of Speech, Language, and Hearing Research*, **44**, 685-702.

BOWEN, C., 2009, *Children's Speech Sound Disorders*. (UK: Wiley-Blackwell).

BRADFORD, A., and DODD, B., 1994, The motor planning abilities of phonologically disordered children. *International Journal of Language and Communication Disorders,* **29**(4), 349-369.

BROOMFIELD, J. and DODD, B., 2004a, Children with speech and language disability: Caseload characteristics. *International Journal of Language and Communication Disability,* **39**, 303-324.

BROOMFIELD, J., and DODD, B., 2004b, The nature of referred subtypes of primary speech disability. *Child Language Teaching and Therapy*, **20,** 135-151.

BROOMFIELD, J., and DODD, B., 2011, Is speech and language therapy effective for children with speech/language impairment? A report of an RCT. *International Journal of Language and Communication Disorders*, **46**, 628-640.

BRYAN, A., and HOWARD, D., 1992, Frozen phonology thawed: The analysis and remediation of a developmental disorder of real word phonology. *European Journal of Disorders of Communication*, **23**(3), 245-365.

CANTWELL, D. P., and BAKER, L., 1988, Issues in the classification of child and adolescent psychopathology. *Journal of the American Academy of Child Psychiatry*, **27**, 521-533.

CORRIN, J. , 2001a, From profile to programme: Steps 1-2. In J. Stackhouse and B. Wells (Eds.), *Children's Speech and Literacy Difficulties: Book 2. Identification and Intervention.* (Chichester, England: Wiley), pp. 96-132.

CORRIN, J., 2001b, From profile to programme: Steps 3-6. In J. Stackhouse and B. Wells (Eds.), *Children's Speech and Literacy Difficulties: Book 2. Identification and Intervention.* (Chichester, England: Wiley), pp. 133-163.

CROSBIE, S., HOLM, A., and DODD, B., 2005, Interventions for children with severe speech disorder: a comparison of two approaches. *International Journal of Language and Communication Disorders,* **40**, 467-492.

CROSBIE, S., HOLM, A., and DODD, B., 2009, Cognitive flexibility in children with and without speech disorder. *Child Language Teaching and Therapy,* **25**, 250-270.

DODD, B., 1995/2005, *Differential Diagnosis and Treatment of Children with Speech Disorder* (London: Whurr Publishers).

DODD, B., 2011, Differentiating speech delay from disorder. Does it matter? *Topics in Language Disorders,* **31,** 2, 96-111.

DODD, B., and BRADFORD, A., 2000, A comparison of three therapy methods for children with different types of developmental phonological disorder. *International Journal of Language and Communication Disorders,* **35**, 189-209.

DODD, B., HUA, Z., CROSBIE, S, HOLM, A, and OZANNE, A., 2002, *Diagnostic Evaluation of Articulation and Phonology* (London, UK: Psychological Corporation).

DODD, B., LEAHY, J., and HAMBLY, G., 1989, Phonological disorders in children: underlying cognitive deficits. *British Journal of Developmental Psychology,* **7**, 55-71.

DODD, B., and MCINTOSH, B., 2008, The input processing, cognitive linguistic and oro-motor skills of children with speech difficulty. *International Journal of Speech-Language Pathology,* **10**, 169-178.

FOX, A. V. and DODD, B., 2001, Phonologically disordered German-speaking children. *American Journal of Speech Language Pathology*, **10**, 291-307.

FOX, A. V., HOWARD, D and DODD, B., 2002, Risk factors for speech disorders in children. *International Journal of Language and Communication Disorders*, **37**(2), 117-131.

GARDNER, H., 2009, Psycholinguistic profiling and intervention. In C. Bowen's, *Children's Speech Sound Disorders*. (UK: Wiley-Blackwell), pp. 138-143.

GIERUT, J.A., 1998, Treatment efficacy: functional phonological disorders in children. *Journal of Speech, Language and Hearing Research*, **41**, 85-100.

GRUNDY, K., 1989, Developmental speech disorders. In K. Grundy (ed.), *Linguistics in Clinical Practice* (London: Academic Press).

GRUNWELL, P., 1981, *The Nature of Phonological Disability in Children* (London: Academic Press).

GRUNWELL, P., 1982/1987, *Clinical Phonology* (London: Croom-Helm).

GRUNWELL, P., 1985, *Phonological Assessment of Children's Speech (PACS)* (Windsor, UK: NFER-Nelson).

GRUNWELL, P., 1997, Developmental phonological disability: Order in disorder. In B.W. Hodson & M. L. Edwards (eds.), *Perspectives in Applied Phonology* (Aspen Publishers), pp.61-104.

HEWLITT, N., 1990, Processes of development and production. In P Grunwell (ed.) *Developmental Speech Disorders* (London: Whurr), pp. 15-38.

HOLM, A., CROSBIE, S and DODD, B., 2005, Treating inconsistent speech disorders. In B. Dodd (ed), *Differential Diagnosis and Treatment of Children with Speech Disorder* (2nd Edition), (London: Whurr), pp 182-201.

HOLM, A., FARRIER, F., and DODD, B., 2008, Phonological awareness, reading accuracy and spelling ability of children with inconsistent phonological disorder. *International Journal of Language and Communication Disorders*, **43**(3), 300-322.

HOWELL, J. and DEAN, E.C., 1991, *Treating Phonological Disorders in Children – Metaphon: theory to practice,* (London: Whurr).

INGRAM, D., 1976, *Phonological Disability in Children*. (London: Edward Arnold).

INGRAM, D., 1997, The categorization of phonological impairment. In B.W. Hodson & M. L. Edwards (eds.), *Perspectives in Applied Phonology* (Aspen Publishers), pp. 19-41.

INGRAM, T.T.S., 1959, Specific developmental disorders of speech in childhood. *Brain*, **82**(3), 450-467.

INGRAM, T. T. S., 1972, Diagnosis, treatment and management of speech defects in childhood. *Proceedings of the Royal Society of Medicine*, **65**, 404-409.

JOFFE, V., and PRING, T., 2008, Children with phonological problems: A survey of clinical practice. *International Journal of Language and Communication Disorders*, **43**, 154-165.

KAMHI, A. G., 1989, Developmental child language disorders. In M. Lahey (Ed.) *Disorders of Communication: An Introduction to Intervention* (London: Taylor and Francis).

LEAHY, J. and DODD, B., 1987, The development of disordered phonology: A case study. *Language and Cognitive Processes*, **2**, 115-132.

LEONARD, L., 1973, Referential effects on articulatory learning. *Language and Speech*, **16**, 44-56.

LEWIS, B.A. (2010). Genetic influences on speech sound disorders. In R. Paul and P. Flipson Jr (ed.), *Speech Sound Disorders in Children: In honor of Lawrence D. Shriberg* (San Diego: Plural Publishing), pp.51-70.

LOCKE, J. L., 1983, Clinical phonology: the explanation and treatment of speech sound disorders. *Journal of Speech and Hearing Disorders*, **48**, 339-341.

MACKEN, M., and FERGUSON, C., 1983, Cognitive aspects of phonological development: model, evidence and issues. In K. Nelson (ed.), *Children's Language* (Hillsdale, NJ: Erlbaum), pp. 255-282.

MCCAULEY, R., 2004, Speech Sound Disorders in Children: Description and Classification. In R. Kent (Ed.) *The MIT Encyclopedia of Communication Disorders*. (Cambridge, Massachusetts; The MIT Press), pp.218-219.

MCCORMACK, J., MCLEOD, S., MCALLISTER, L., and HARRISON, L. J., 2009, A systematic review of the association between childhood speech impairment and participation across the lifespan. *International Journal of Speech-Language Pathology*, **11**(2), 155-170.

MCLEOD, S., and HARRISON, L. J., 2009, Epidemiology of speech and language impairment in a nationally representative sample of 4-to-5-year old children. *Journal of Speech, Language, and Hearing Research*, **52**, 1213-1229.

MENN, L., 1978, Phonological units in beginning speech. In A. Bell and J. B. Hooper (Eds.), *Syllables and Segments*. (New York: Elsevier-north Holland), pp. 157-172.

NATHAN, L., and SIMPSON, S., 2001, Designing a literacy programme for a child with a history of speech difficulties. In J. Stackhouse and B. Wells (Eds.), *Children's Speech and Literacy Difficulties: Book 2. Identification and Intervention.* (Chichester, England: Wiley), pp. 249-298.

NEWBURY, D. F., and MONACO, A. P., 2010, Genetic advances in the study of speech and language disorders. *Neuron*, **68**, 309-320.

PASCOE, M., STACKHOUSE, J., and WELLS, B., 2005, Phonological therapy within a psycholinguistic framework – promoting change in a child with persisting speech difficulties. *International Journal of Language and Communication Disorders*, **40**(2), 189-220.

PASCOE, M., STACKHOUSE, J., and WELLS, B., 2006, *Children's Speech and Literacy Difficulties: Book 3. Persisting Speech Difficulties in Children.* (Wiley: Chichester, England)

PRESTON, J., and EDWARDS, M.L., 2010. Phonological awareness and types of sound errors in preschoolers with speech sound disorders. *Journal of Speech, Language, and Hearing Research,* **53**, 44-60.

PRESTON, J., and KOENIG, L.L., 2011, Phonetic variability in residual speech sound disorders; Exploration of subtypes. *Topics in Language Disorders*, **31**(2), 168-184.

REES, R., 2008, *Deaf children's acquisition of speech skills: A psycholinguistic perspective through intervention.* Unpublished doctoral thesis, University College, London.

RUSCELLO, D. M., 2008, *Treating Articulation and Phonological Disorders in Children* (St Louise, MO; Elsevier).

SHRIBERG, L.D., 1994, Five subtypes of developmental phonological disorders. *Clinics in Communication Disorders,* **4,** 38-53.

SHRIBERG, L., 1997, Developmental phonological disorders: One or many? In B. W. Hodson and M. L. Edwards (eds.) *Perspectives in Applied Phonology* (Gaithersburg, MD: Aspen), pp.105-132.

SHRIBERG, L. D., 2006 June, Research in idiopathic and symptomatic childhood apraxia of speech. Paper presented at the *5th International Conference of Speech Motor Control* Nijmegen, the Netherlands.

SHRIBERG, L. D., 2010, Childhood speech sound disorders: From postbehavorism to the postgenomic era. In R. Paul and P. Flipsen, Jr (eds.) *Speech Sound Disorders in Children – in honor of Lawrence D. Shriberg* (Plural Publishing Inc: San Diego,CA), pp. 1-34.

SHRIBERG,L. D., FOURAKIS, M., HALL, S. D., KARLSSON, H. B., LOHMEIER, H. L., MCSWEENEY, J., POTTER, N. L., SCHEER-COHEN, A. R., STRAND, E. A., TILKENS, C. M., and WILSON, D. L., 2010a, Extensions to the speech disorders classification system (SDCS). *Clinical Linguistics and Phonetics,* **24**(10), 795-824.

SHRIBERG, L. D., FOURAKIS, M., HALL, S. D., KARLSSON, H. B., LOHMEIR, H. L., MCSWEENEY, J., POTTER, N. L., SCHEER-COHEN, A. R., STRAND, E. A., TILKENS, C. M., and WILSON, D. L.,2010b, Perceptual and acoustic reliability estimates for the Speech Disorders Classification System (SDCS). Clinical Linguistics and Phonetics, **24**(10), 825-846.

SHRIBERG, L. D., KENT, R. D., KARLSSON, H. B., MCSWEENY, J. L., NADLER, C. J., and BROWN, R. L., 2003, A diagnostic marker for speech delay associated with otitis media with effusion: backing of obstruents. *Clinical Linguistics and Phonetics*, **17,** 529-547.

SHRIBERG, L. D., and KWIATKOWSKI, J., 1991, Developmental phonological disorders 1: A clinical profile. *Journal of Speech and Hearing Research*, **37**, 1100-1126.

SMITH, N., 1973, *The Acquisition of Phonology: A Case Study* (Cambridge: Cambridge University Press).

SO, L. and DODD, B., 1994, Phonologically disordered Cantonese-speaking children. *Clinical Linguistics and Phonetics*, **8**, 235-255.

STACKHOUSE, J., NATHAN, L., GOULANDRIS, N., and SNOWLING, M., 2002, *The Relationship Between Speech Disorders and Literacy Problems: Identification of the At Risk child. Report on a 4 year Longitudinal Study to Research and Development* (London: North Thames Regional Health Authority).

STACKHOUSE, J., PASCOE, M., and GARDNER, 2006, Intervention for a child with persisting speech and literacy difficulties: A psycholinguistic approach. *Advances in Speech-Language Pathology*, **8**(3), 231-244.

STACKHOUSE, J., and SNOWLING, M., 1992, Developmental verbal dyspraxia II: A developmental perspective on two case studies. *European Journal of Disorders of Communication,* **27**(1), 35-54.

STACKHOUSE, J., VANCE, M., PASCOE, M., and WELLS, B., 2007, *Compendium of Auditory and Speech Tasks* (West Sussex: John Wiley & Sons).

STACKHOUSE, J., and WELLS, B., 1993, Psycholinguistic assessment of developmental speech disorders. *European Journal of Disorders of Communication*, **28**, 331-348.

STACKHOUSE, J., and WELLS, B., 1997, *Children's Speech and Literacy Difficulties: A Psycholinguistic Framework* (London: Whurr).

STACKHOUSE, J., and WELLS, B., 2001, *Children's Speech and Literacy Difficulties: Book 2. Identification and Intervention.* (Chichester, England: Wiley)

TAYLOR, E., 2011, How to classify? *Journal of the American Association of Child and Adolescent Psychiatry,* **50**(2), 103- 105.

TYLER, A. A., 2010, Subgroups, comorbidity, and treatment implications. In R. Paul and P. Flipsen, Jr (eds.) *Speech Sound Disorders in Children – in honor of Lawrence D. Shriberg* (Plural Publishing Inc: San Diego,CA), pp. 71-92.

VANCE, M., 1997, Developing phonological representations in a child with an auditory processing deficit. In S.Chiat, J. Law, and J. Marshall (Eds.), *Language Disorders in Children and Adults: Psycholinguistic Approaches to Therapy*. (London: Whurr), pp. 17-41.

WATERS, D., 2001, Using input processing strengths to overcome speech output difficulties. In J. Stackhouse and B. Wells (Eds.), *Children's Speech and Literacy Difficulties: Book 2. Identification and Intervention.* (Chichester, England: Wiley), pp. 164-2003.

WATERS, D., HAWKES, C., AND BURNETT, E., 1998, Targeting speech processing strengths to facilitate pronunciation change. *International Journal of Language and Communication Disorders*, **33** (supplement), 469-474.

WATERSON, N., 1987, *Prosodic Phonology: the Theory and its Application to Language Acquisition and Speech Processing* (Newcastle upon Tyne: Grevatt & Grevatt).

WINITZ, H., 1975, *From Syllable to Conversation* (Baltimore: University Park Press).

WORLD HEALTH ORGANIZATION, 2001, *ICF: International Classification of Functioning, Disability and Health*. Geneva: World Health Organization.

WORLD HEALTH ORGANIZATION (WHO Workgroup for development of version of ICF for Children and Youth), 2007, *International Classification of Functioning, Disability and Health – Version for Children and Youth: ICF-CY*. Geneva: World Health Organization.

ZELAZO, P., and MULLER, U., 2002, Executive function in typical and atypical development. In U. Goswami (Ed.), *Handbook of Childhood Cognitive Development.* (Oxford: Blackwell), pp.445-469.

ZHU HUA, and DODD, B., 2000, Putonghua (modern standard Chinese)-speaking children with speech disorder. *Clinical Linguistics and Phonetics*, **14**, 165-191.