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1 **Early identification of children at risk of communication disorders:**

2 **Introducing a novel battery of Dynamic Assessments for infants**

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29 **Abstract**

30 *Purpose*

31 Many children with communication disorders (CD) experience lengthy gaps between parental reporting of
32 concerns and formal identification by professionals. This means that children with CD are denied access to
33 early interventions that may help to support the development of communication skills and prevent possible
34 negative sequelae associated with long-term outcomes. This may be due, in part, to the lack of assessment
35 instruments available for children younger than three years of age. This study therefore reports on
36 promising preliminary data from a novel set of valid dynamic assessment measures designed for infants.

37 *Methods*

38 We recruited 53 low-risk children and two groups of children considered to be at high risk for CD (n=17
39 social-high-risk and n=22 language high-risk) due to family members with language and social
40 communication difficulties. Children were between 1 and 2 years of age and were assessed using a battery
41 of five dynamic assessment (DA) tasks related to receptive vocabulary, motor imitation, response to joint
42 attention, turn taking and social requesting. A set of standardised measures was also used.

43 *Results*

44 The DA tasks showed high levels of inter-rater reliability and relationships with age across a cross-sectional
45 sample of children from the low-risk group. Three tasks showed moderate to strong correlations with
46 standardised measures taken at the same age, with particularly strong correlations between the DA of
47 receptive vocabulary and other receptive language measures. The DA of receptive vocabulary was also the
48 only task to discriminate between the three risk groups, with the social-high-risk group scoring lower.

49 *Conclusions*

50 These results provide preliminary information about early DA tasks, forming the basis for further research
51 into their utility. DA tasks might eventually facilitate the development of new methods for detecting CD in
52 very young children, allowing earlier intervention and support.

53

54

55 **Introduction**

56 Many children experience communication difficulties that require intervention during development. Autism
57 and Developmental Language Disorder (DLD) represent two of the most prevalent disorders of childhood.
58 Roughly 2% (Roman-Urrestarazu et al, 2021) and 8% (Norbury et al, 2016) of all children experience these
59 disorders respectively, and there is compelling evidence that there are lifelong sequelae including
60 employment issues (Autism: Harmuth et al, 2018; DLD: Dubois et al, 2020) as well as for mental health
61 (Autism: Hollocks et al, 2019; DLD: Botting et al, 2016). Yet, for DLD especially, there is relatively low
62 awareness (Thordardottir et al, 2021) and a paucity of research compared to other developmental disorders
63 (Bishop, 2010; McGregor, 2020). There is a view that early intervention is optimum for these children, as
64 language difficulties associate with wider long-term difficulties such as memory impairment (Henry &
65 Botting, 2017), poorer educational attainment and employment prospects (Conti-Ramsden et al, 2018) and
66 increased mental health issues (Botting et al, 2016). However, very early diagnosis and associated
67 intervention services are not yet recommended in many countries including the UK, (e.g. Lindsay et al, 2008;
68 Boyle, 2011; Wallace et al, 2015; Reilly et al, 2015; Bishop et al, 2017; Law et al, 2020; Jullien et al, 2021), in
69 part because there are limited reliable assessments which can accurately identify infants with
70 communication difficulties before the age of 3. In this paper we present preliminary data from a set of novel
71 assessment tasks as a first step towards developing tools for identifying very early social and communication
72 difficulties. We have focussed this ‘proof of concept’ study on groups of children at risk of Autism and DLD
73 because of their combined prevalence and also because these are groups where we expect communication
74 difficulties to show early signs; however, tools that are applicable to communication difficulties in other risk
75 groups would be a wider long-term aim.

76

77 ***Autism***

78 Autism is a lifelong pervasive developmental disorder which is diagnosed on the basis of impairments of
79 social communication and social interaction, alongside restricted and repetitive behaviours (American
80 Psychiatric Association, 2013). Recent prevalence estimates indicate that approximately one in every 68

81 children aged four in the USA has an ASD (Christensen, et al., 2016) and that this figure is approximately 4.5
82 times as high for boys than for girls (1 in 42 as opposed to 1 in 189 respectively; Christensen, et al., 2016). A
83 similar estimate of prevalence was derived for the UK by Baron-Cohen et al (2009), although only 60% of
84 these cases were formally diagnosed before study participation. Because ASD is a spectrum condition, it is
85 vastly heterogeneous in its presentation. Language abilities can range from minimal use of, or
86 comprehension of spoken language, to intact structural language skills in the context of difficulties with
87 pragmatic skills, or language use. ASD can occur both with and without learning disability, and recent
88 estimates suggest that 44% of children with ASD have average or above average intellectual ability
89 (Christensen, et al., 2016). Regression of communication and adaptive skills, usually in the second year of
90 life, is also reported in a subset of cases (Meilleur & Fombonne, 2009).

91

92 ***Developmental Language Disorder (DLD)***

93 DLD is the preferred label for language difficulties of unknown aetiology in children, including conditions that
94 were previously referred to as Specific Language Impairment or Developmental Dysphasia (Bishop et al,
95 2017). DLD affects approximately 7-8% of children at school-starting age (Tomblin, et al., 1997; Norbury, et
96 al., 2016) and typically occurs in the absence of hearing loss, neurological impairment or severe
97 environmental deprivation which would explain difficulties with language learning. Previous criteria for
98 Specific Language Impairment required normal non-verbal intellectual ability and/or a discrepancy between
99 language skills and IQ, but it has recently been established that there are few significant differences between
100 children with language difficulties in the presence of typical IQ and children who have low abilities in both
101 language and cognition, and IQ criteria are therefore no longer used to define DLD (Bishop et al, 2017;
102 Norbury, et al., 2016). The presentation of DLD is also heterogeneous and may involve difficulties at any level
103 of language processing, including phonology, morphology, syntax, semantics or pragmatics. Individual
104 children may be affected across one or multiple levels of language and across either receptive or expressive
105 modalities or both. The relationship of DLD to delayed language acquisition (or “late talking”) in early
106 childhood is complex, (e.g., Dale et al., 2003; Reilly et al., 2010; Zambrana et al, 2014; Duff et al., 2015;

107 Rudolph & Leonard, 2016), and early language delays are not always predictive of later language impairment
108 on an individual level. However, at least some children who have DLD are known to have difficulties with
109 spoken language throughout the lifespan (Botting, 2020).

110

111 ***Age of Identification***

112 The age at which children with communication disorders are identified has important implications for early
113 intervention and support. The potential consequences of not identifying and providing input for children
114 with communication disorders are large (Hus & Segal, 2021) and may include poorer employment prospects
115 (Chen et al., 2017; Conti-Ramsden et al., 2017); increased mental health difficulties (Botting et al., 2016);
116 and economic costs for society (Rogge & Janssen, 2019). For ASD, Zwaigenbaum et al (2009) found that most
117 parents of children later diagnosed with ASD identified concerns about their children’s development
118 between 12 and 18 months of age, including concerns regarding delayed language development, limited play
119 skills, decreased social responsiveness, extreme behavioural reactions to external stimuli and difficulties with
120 sleep or feeding. Some parents report even earlier concerns starting before 12 months of age (Zwaigenbaum
121 et al., 2005; De Giacomo and Fombonne, 1998; Filipek et al., 1999). However, as noted above, early
122 identification is not straightforward, and reported age of diagnosis in ASD tends to be much older than
123 reported age of first concern. Mean age of diagnosis varies between studies and across countries, with a
124 review by Daniels and Mandell (2014) reporting means ranging from 32 to 120 months of age across
125 different studies, and a recent meta-analysis reporting a mean age of autism diagnosis of 60.5 months based
126 on studies from 40 countries (van’t Hof et al, 2021). Other recent studies suggest similar age of diagnosis: a
127 mean of 46 months of age in Australia (Bent et al, 2020), 58 months in France (Rattaz et al, 2022) and 54
128 months in the USA (Hanley et al, 2021). Indeed, recent prevalence data from the USA suggests that, of 4681
129 children with an autism diagnosis at the age of 8, only 47% received a diagnosis before the age of 3
130 (Maenner et al, 2021). Importantly, in the UK context, Crane et al (2016) report an average delay of
131 approximately 3.5 years between first contact with health professionals and confirmed diagnosis in their
132 survey of parents of children with ASD, and only 11% of children in their sample were diagnosed before the

133 age of three. Cohort studies also emphasise the rate of later diagnosis in ASD, with the number of diagnosed
134 children in the Early Language in Victoria Study (ELVS) more than doubling between the ages of four and
135 seven (Veness et al 2014), and percentages of children diagnosed with ASD rising from 0.9% at age five to
136 1.7% at age seven and 3.5% at age 11 within the Millennium Cohort Study (Dillenburger et al, 2015).

137 Although some children do receive intervention services before they have a diagnosis, these do not appear
138 to start significantly earlier (mean age for first receipt of services = 4.1 years; Hanley et al, 2021).

139

140 There is less information on diagnosis/recognition of difficulties among children with DLD, but Rannard et al
141 (2004) reported that a quarter of parents in their sample noticed difficulties in their children's language and
142 communication between 12 and 18 months of age, and a further quarter between 18 and 24 months of age,
143 making around 50% showing concern by the time their child reached their second birthday. Absent or
144 unusual babbling, poor intelligibility and late language onset were the main areas of concern noticed by
145 parents. However, despite roughly half of parents being concerned about their child's communication skills
146 by the age of two, only one third of the children in this study received any input from speech and language
147 therapy services before the age of three, and 21% had no support until they started school (Rannard et al,
148 2004). Similarly, Tomblin et al (1997) found that only 29% of children who showed evidence of language
149 impairment in Kindergarten had ever been referred to speech and language therapy services. In a more
150 recent study in the UK, Norbury et al (2016) found that, of 9.92% of children who had language difficulties at
151 school entry, only 39% had ever been referred to SLT services, and only 40% received any additional support
152 at school. This figure may be higher in other countries, but a recent study in the USA also found that not all
153 children who have speech and language difficulties are receiving SLT support, with only around 75% ever
154 having received services for these difficulties during their lifetime (Davidson et al, 2022). Thus, there is a
155 need to work towards more sensitive early measures of language and social communication, tapping into
156 pre-verbal behaviours, such as joint attention and turn-taking, which form the foundations of language
157 development (Curtin et al, 2021).

158

159 UK Referral figures for children of different ages confirm these results from both disorders, with Broomfield
160 and Dodd (2011) finding that only 6% of referrals made to one speech and language therapy service under
161 study were for children under two, 67% between the ages of two and five, and 27% for children of five or
162 older. The Bercow Report (Bercow, 2008) also highlighted that UK parents continue to have difficulties
163 accessing speech and language therapy services and 28% of those who responded felt they had had to fight
164 for their child to receive a diagnosis and associated services. As noted earlier, inefficient diagnostic
165 pathways may lead to poorer outcomes across a variety of areas in later life for children with communication
166 impairments (Hus & Segal, 2021).

167

168 ***Current assessment issues***

169 There may be many reasons for delayed identification, including limitations in the training of professionals in
170 early assessment, resource issues and service eligibility criteria (Huerta & Lord, 2012). However, certainly in
171 the UK and US, there is generally a lack of valid assessments appropriate for infants. Where they are used,
172 the likelihood of social, cultural and linguistic bias is high (Dockrell & Marshall, 2015), untested adaptations
173 are sometimes made (Cycyk et al, 2021), and the arbitrary cut-off scores are problematic (Spaulding, Plante
174 & Farinella, 2006). Furthermore, the appropriateness of a given test is often not considered properly in
175 practice (Friberg, 2010; Betz et al, 2013). Thus, the addition of appropriate, culturally and linguistically
176 sensitive infant assessment tools, is one area where there is need for urgent improvement to avoid the
177 consequences of late- or missed-diagnoses (Hus & Segal, 2021). In particular, the current model relies
178 heavily on impairment focused assessments that use formal, static approaches – that is measures which tap
179 into performance at once time point, without considering process (Spaulding et al, 2012; Roulstone et al,
180 2015; Dockrell & Marshall, 2015). These assessments are primarily designed to identify children scoring
181 below a particular threshold rather than predicting risk or assessing change over time. (Hasson & Botting,
182 2010). When considering very young children, especially those at risk of communication difficulties, these
183 tests may not serve the purpose of assessing possible difficulties because they are not feasible with infants,
184 and because infants tend to show a wide range of ability at a given age (Law & Roy, 2008).

185

186 Speech and language therapists, teachers, psychologists and others who assess children using static tests
187 have long known that there are some groups of children who are not well-served by traditional formal
188 assessment methods (e.g. Spaulding et al, 2012). There are many reasons why a child may fail to perform
189 well under static testing conditions, including cultural and linguistic diversity, shyness, difficulties with
190 attention regulation, difficulties with social interaction and lack of familiarity with the formal testing process,
191 as well as difficulties with the specific knowledge and skills being assessed (Chiat & Roy, 2007; Camilleri &
192 Law, 2007; Hasson & Joffe, 2007). Because static testing usually seeks to remove the effects of the individual
193 examiner by making the testing process exactly the same for each child, without environmental support or
194 examiner feedback, it tells us only how the child performs on a specific measure under those conditions on a
195 specific day. What it does not tell us is how the same child performs in more natural situations, or where
196 they are engaged with the examiner in a collective effort to generate correct responses (Peña et al, 2007).
197 This causes an issue with validity whereby the static assessment only captures a one-point estimate of the
198 construct, rather than the construct itself (Messick, 1998; Hasson & Joffe, 2007; Camilleri & Law, 2007;
199 Spaulding et al, 2012) and yet at the same time fails to eliminate all tester input effects (Muskett, Body &
200 Perkins, 2012). Thus, a different approach is needed. Practitioners often take the approach of very informal
201 observation or reliance on parent report (for example, by health visitors or doctors; Law et al, 2020) to
202 counter the lack of formal assessment, but using a 'Dynamic Assessment' to measure emerging skills and
203 learning potential offers a middle ground providing flexible yet objective measurement (Bamford et al,
204 2022).

205

206 ***Dynamic Assessment (DA)***

207 In contrast to the static formal testing usually used by speech and language therapists, DA is more focused
208 on the process of learning, and what a child's potential level of performance is, when supported by an adult
209 who can provide prompting, cueing or teaching to help them improve their performance on the task . DA
210 arose originally out of the socio-cultural theory of Vygotsky (1978), who described the "zone of proximal

211 development” (ZPD) of the child’s skills in any area of learning. This describes the gap between the child’s
212 habitual unaided performance and the level that they are able to reach when supported by an adult or more
213 experienced peer. That is, children’s learning potential can be measured by observing what they can achieve
214 in a scaffolded paradigm, rather than just their performance in an unaided scenario (Hasson & Joffe, 2007).
215 This difference in static and dynamic methods has been noted and built on for school age children and now
216 has widespread awareness (Deutsch & Reynolds, 2000) and some practice among some school psychologists
217 (Hussein & Woods, 2019). However, to our knowledge no work has been done exploring the use of DA in
218 preverbal infants.

219
220 Sternberg and Grigorenko (2002) described two main formats into which DA methodologies can be
221 organised: the “sandwich” and the “cake” (see a recent description by Bamford et al, 2022). The use of test-
222 teach-retest dynamic assessment procedures may be referred to as a “sandwich”, in which children are
223 tested using static assessments before and after a brief intervention, to reveal the amount of change, or
224 ‘gain’ that has taken place. The teaching phase typically involves a metacognitive element, which enables the
225 child to learn which elements/strategies are required for successful completion of the task in question.
226 Ratings of the child’s responsiveness during the ‘teach’ phase, together with the gains achieved between the
227 test and the retest provide an indication of the child’s potential to learn. Within the field of speech and
228 language assessment, this methodology has been adopted for the diagnostic purpose of distinguishing
229 between low language ability and typically developing preschool children from specific culturally and
230 linguistically diverse groups in the United States of America (Kapantzoglou et al., 2012; Peña et al, 2014).
231 Static, standardised assessments can be biased against these children, leading to low scores for both
232 typically developing children as well as children with language disorders. Dynamic assessments were found
233 to reduce this bias, when assessing a range of areas including vocabulary (Kapantzoglou et al., 2012; Pena,
234 Iglesias & Lidz, 2001), categorization (Ukrainetz, Harpell, Walsh and Coyle, 2000) and narrative (Pena et al.,
235 2006).

236

237 The “cake” format, which sometimes forms the centre part of the ‘sandwich’ (see below for hybrid
238 methods), is perhaps more suitable when assessing very young children, below the age of four. This method
239 usually involves the integration of graduated prompts or feedback into the assessment session, as described
240 by Campione and Brown (1987) and Carlson and Wiedl (1978) and used more recently by researchers such as
241 Patterson et al. (2020) in preschool children. The examiner provides support to the child as they are
242 completing the assessment, typically using a pre-determined cueing hierarchy that provides the child with
243 increasingly explicit support to reach the correct answer or complete the task. What is measured here and
244 interpreted as the size of the ZPD is the number of cues given to the child to enable them to complete the
245 task, with more favourable scores being achieved by children who require less cueing to achieve success
246 (Campione & Brown, 1987). This methodology was previously adopted with young preschool children (aged
247 30 to 36 months), who had a specific difficulty with expressive language (Bain & Olswang, 1995; Olswang &
248 Bain, 1996). This DA targeted the immediate potential for children performing at the one-word stage of
249 expressive language development, to produce two-term utterances, by using a series of graduated prompts
250 which facilitated production of the two-term utterance. These prompts included elicitation questions,
251 sentence completion and direct/indirect modelling. The key findings were that children’s scores on the DA
252 were highly predictive of change over a nine-week period, both with (Bain & Olswang, 1995) and without
253 intervention (Olswang & Bain, 1996).

254

255 Some DA research with young children in the United Kingdom and Europe has adopted a hybrid approach,
256 incorporating both graduated prompts and an element of metacognitive intervention (Hasson et al., 2013;
257 Camilleri, Hasson & Dodd, 2014). This has included research looking at bilingual and multilingual children in
258 their first year of schooling (MacLeod & Glaspy, 2022). One big difference between this research and that
259 from the USA is that children in the UK/Europe derive from a wide range of bilingual backgrounds, whereas
260 the children in the studies cited above from the USA were recruited from specific linguistic backgrounds
261 (e.g., Hispanic or Native American). The UK studies compared typically developing bilingual children and
262 bilingual children with developmental language delays (on the Speech and Language Therapy caseload). The

263 findings were that caseload children required greater assistance and made fewer gains in both vocabulary
264 and sentence production (Hasson et al., 2013; Camilleri et al., 2013), further extending the evidence base
265 that DA can be used to distinguish between these two groups. All but one of the children with
266 developmental language delays were found to experience difficulties with components of the DA
267 assessment (Camilleri et al., 2013).

268

269 Of the different approaches mentioned above, the graduated prompt approach is particularly suited when
270 working with very young children, as it does not require the explicit metacognitive element that is crucial to
271 the 'sandwich' or test-teach-retest approach. Although recent reviews by Hunt et al, (2019) and Orellana et al
272 al (2019) indicate that test-teach-retest methods are mostly chosen, the meta-analysis by Orellana et al
273 (2019) concluded that modifiability ratings (similar to those used in the graduated prompts approach)
274 showed more promise as an indicator of typical development vs. language impairment at least in bilingual
275 children. This is therefore the approach which has been selected for the current study.

276

277 ***Present study***

278 As discussed above, there is currently an emerging evidence base for the use of DA in speech and language
279 therapy. Although the evidence to date is mainly from small-scale studies (see Joffe & Hasson, 2007;
280 Orellana et al, 2019), there is a growing awareness in the field suggesting that DA can be used successfully
281 with preschool children to determine the presence or absence of language and communication impairment,
282 and in order to suggest strategies that may be used to support children in their communication
283 development, or predict how children will respond to intervention (Hunt et al, 2019). This paper aims to
284 address some gaps identified in the literature, including exploring the application of DA to children under
285 two years of age, and the use of DA with high-risk children as a predictor of later language and
286 communication skills. The areas of focus for these new DA tasks encompass 5 key communicative gestures
287 and behaviours that have been reported in the literature as predictors of later language or as delayed in
288 children with later social communication difficulties (Law et al, 2017; Rohlfing, 2019; Ramos-Cabo et al,

289 2019). Namely these areas comprise: Early receptive vocabulary (Markus et al, 2000); Response to joint
290 attention (Salo et al, 2018); Motor imitation (Hanika & Boyer, 2019); Turn taking (Hendenbro et al, 2014);
291 and non-verbal requesting behaviour (Ramos-Cabo et al, 2019). We acknowledge that the full development
292 of a new DA tool for clinical practice will take many iterations. Thus, the objective here is to present work to
293 establish initial 'proof of concept' and feasibility of an early infant measure.

294 The aims of the study were threefold:

- 295 1. To investigate whether reliable normative scores can be gained from a novel battery of very early DA
296 procedures for use with infants under two years of age who have no first-degree relatives with
297 communication or literacy difficulties.
- 298 2. To assess performance on these measures in relation to age, sex and standardised tests of
299 communication in a low-risk group of children (normative sample).
- 300 3. To explore whether there are early indicators of (known groups) validity, using preliminary
301 comparisons of infants at high-risk of communication disorders (siblings or parents with ASD, DLD or
302 Dyslexia) with low-risk infants (siblings or parents with no known difficulties).

303

304 **Method**

305 ***Recruitment***

306 Recruitment took place via social media, where contacts of the researchers were encouraged to share the
307 project website on their own feeds. Parents of children in the correct age range could then visit the project
308 website, view the project information sheet, and contact the research team if they agreed to take part.

309 Children with bilingual exposure were not excluded from this sample, as long as they were exposed to
310 English as one of the main languages of the home and could be assessed in English¹ Informed consent was
311 taken from parents of all infants at the start of the research visit. The infants who participated were too
312 young to give formal assent, but willingness to interact with the researcher and participate in activities was

¹ For the purposes of developing this task, English was the only language assessed. However, we acknowledge that in clinical practice, it is preferable to assess all home languages.

313 taken to indicate assent. The study was granted ethical approval from City University of London, Language
314 and Communication Science Research Ethics Committee.

315

316 ***Participants***

317 Two groups of children participated in the study: those at low-risk (n=51) and high-risk (n=41) of
318 communication difficulties based on family history. The novel tasks were assessed for feasibility, reliability
319 age relations and preliminary validity using the low-risk group only, to establish how the test performs for a
320 normative sample (Pena, Spaulding & Plante, 2006). The high-risk groups were then used to compare scores
321 to explore clinical usefulness and preliminary known-group validity.

322

323 *Low-risk children (with typical siblings and parents)*

324 Participants in the first part of this study were 51 low-risk children (25 female and 26 male) and had a mean
325 age of 12.2m ($SD = 3.0$) at the time of assessment (see Table 1 for demographics). The majority of this group
326 were white British (n = 37) with 4 who had mixed ethnicity, 2 who were Asian and 2 reported as being of
327 'other' ethnicity (6 children had no ethnicity data recorded). The inclusion criteria for this group were that
328 children had no known developmental, physical or sensory difficulties at the time of recruitment, and their
329 parents and elder siblings showed no evidence of language, communication or literacy difficulties. This
330 sample included five children who were exposed to other European languages within their home in addition
331 to English (Swedish (n=1), Finnish (n=1), German (n=2) and Italian (n=1), with exposure to their additional
332 language varying between 20 to 40 hours per week ($M = 24.8$; $SD = 8.6$) as reported by parents on the UKCDI
333 demographic questionnaire (Alcock et al, 2020). Children were largely recruited from Greater London
334 (72.5%) although some were from other parts of England.

335

336 In total 31 of the children were first-born, and had parents with no reported history of difficulties with
337 language, social communication or literacy development. Twenty children had older siblings (n=26 siblings),
338 who were reported by parents to be developing typically. Parents completed the Children's Communication

339 Checklist (CCC-2) (Bishop, 2003) for 18 elder siblings of children in the sample who were aged 4;0 and above.
340 All 18 elder siblings scored within the average range for the General Communication Composite score on the
341 CCC-2, indicating no communication impairments, and none scored within the range of clinical concern on
342 the Social Interaction Deviance Composite score. Of the remaining 8 siblings, 4 were older than 4;0 but did
343 not have a CCC-2 completed by parents, and 4 were younger than 4;0 and therefore the CCC-2 could not be
344 completed. However, in all cases, parents reported no concerns about their development. Additionally, 3 out
345 of 4 siblings under the age of 4;0 were present during the assessment of the infant in the study, and were
346 judged by the first researcher, who is an experienced speech and language therapist, to have language and
347 communication skills within the typical range for their age. All elder siblings were therefore assumed to be
348 typically developing. In addition, none of these 21 infants had parents who reported a history of difficulties
349 with language, literacy or social communication.

350

351 Demographic data showed that 79.0% of mothers and 81.8% of fathers of these infants were aged 31 or
352 older. The sample had high levels of parental education, with 95.5% of mothers and 86.4% of fathers
353 reporting an undergraduate or postgraduate degree, and no parents reporting no formal educational
354 qualifications. Overall, 76.7% of the sample reported family annual income of £42,000 or more. It is
355 therefore acknowledged in the data that follow that these infants may not be representative across a
356 broader range of socioeconomic status. See statistical group comparisons below.

357

358 *High-risk children*

359 For the final research question, a further 41 children were recruited who were considered at high risk of
360 communication difficulty on account of their siblings or parents having existing developmental disorders.
361 These children fell into 2 groups with the following inclusion criteria: i) those with siblings who had a
362 diagnosis of autism or social communication disorder or were being assessed for this diagnosis, or whose
363 siblings fell below the clinical threshold for the Social Interaction Deviance Composite score on the Children's
364 Communication Checklist, 2nd Edition (CCC-2; Bishop, 2003). We refer to this group as the Social-High-Risk

365 (SHR) group; ii) infants with siblings and/or parents who had a diagnosis of Developmental Language
366 Disorder, Dyslexia or other Speech Language and Communication Needs, or who were late to speak (defined
367 as fewer than 50 single words at the age of two). We refer to these children as the Language-High-Risk (LHR)
368 group. Children were not excluded on the basis of siblings with other genetic syndromes but infants with
369 genetic syndromes, physical disabilities or sensory impairments were excluded. High-risk children were
370 recruited from across England and are detailed below.

371

372 In the SHR group there were 18 children, 10 female and 8 male, with a mean age of 15.4 months ($SD = 3.9$).
373 Of these 11 were white British and 1 was of mixed ethnicity (6 children with missing ethnicity data). Ten of
374 these children had elder siblings or half-siblings with a confirmed ASD diagnosis. For the other 8 elder
375 siblings, concerns were raised by parents about their social interaction skills. Where the elder sibling was
376 aged 4;0 or above, parents completed the CCC-2, and a conservative Social Interaction Deviance Composite
377 (SIDC) score of -10 or less was taken to indicate the presence of a social communication impairment in elder
378 siblings who did not have an ASD diagnosis. Where the elder sibling was aged less than 4;0, the younger child
379 was considered to fall into the SHR group if the elder sibling was under assessment for an ASD diagnosis.
380 Two of the eight elder siblings without a formal autism diagnosis had been given a diagnosis of Social
381 Communication Difficulties by a Speech and Language Therapist; a further child had previously been
382 assessed for ASD and not given the diagnosis (although traits that could be consistent with mild ASD were
383 identified), and two were currently undergoing ASD assessment. For three undiagnosed elder siblings,
384 parents did not refer specifically to ASD when describing their elder child but made reference to difficulties
385 interacting with others. All of these children showed low SIDC scores on the CCC-2 whilst no sibling of any
386 child in the low-risk or LHR group had SIDC scores that would indicate significant social impairment. Two
387 elder siblings in this group had additional diagnoses: one of Attention Deficit Disorder and one of Cri-Du-Chat
388 Syndrome. One SHR child was exposed to another language (French) for 24 hours a week. In total 16.7% of
389 SHR children were from Greater London.

390 In the LHR group there were 23 children, 15 female and 8 male, with a mean age of 13.2 months ($SD = 3.0$).
391 Sixteen were white British and 5 were of mixed ethnicity (2 children had missing ethnicity data). Eight
392 children in this group had elder siblings or half-siblings with concurrent speech and language difficulties, and
393 three had parents, elder siblings or half-siblings with a history of late language emergence (no single words
394 before the age of two). The remaining 12 children had parents and/or siblings/half-siblings with a diagnosis
395 of dyslexia. In two out of eight cases of concurrent LI, the elder siblings also had learning difficulties and
396 global developmental delays. In cases where elder siblings were 4;0 or older and speaking in sentences, the
397 CCC-2 was used to confirm that they had impairments of language but did not have social communication
398 difficulties. Where the elder sibling was younger than 4;0, their parents reported in all cases that they were
399 receiving support from Speech and Language Therapy services for language or speech and that no concerns
400 had been raised about social communication. In total, 47.8% of LHR children were from the Greater London
401 area and one child was exposed to Spanish for 15 hours a week.

402

403 *Demographic group comparisons*

404 The parental age profile of the high-risk group was similar to that of the low-risk group, with 91.7% of
405 mothers and 83.4% of fathers in the SHR group, and 86.3% of mothers and 91.0% of fathers in the LHR group
406 aged 31 or older. Chi squared analysis using three age categories (30 or younger, 31 to 35 and 36 or older)
407 showed a similar pattern of maternal ($\chi^2 (4) = 0.893, p=0.926$) and paternal age ($\chi^2 (4) = 0.911, p=0.923$)
408 across groups.

409 Parental education levels were lower for both mothers and fathers in the SHR group, and for fathers in the
410 LHR group, than the low-risk group (66.7% of mothers and 58.3% of fathers in the SHR group and 95.5% of
411 mothers and 68.2% of fathers in the LHR group reported having an undergraduate or postgraduate degree).
412 A significant group difference was found for maternal education level (with categories up to and including
413 Level 3 qualifications collapsed²; ($\chi^2 (4) = 12.376, p=0.015$), such that the SHR group contained more

² Level 3 qualifications are end of high-school qualifications such as A-Levels usually taken at 18 years of age

414 mothers educated to Level 3 or lower, and fewer mothers educated at degree or postgraduate level than the
415 other groups. Analysis of paternal education level using the same categories revealed that group differences
416 were not statistically significant ($\chi^2 (4) = 8.049, p=0.090$). Family income across three categories (£24,000 or
417 less, £24,001 to £42,000, and £42,000 or more) also did not differ significantly across groups ($\chi^2 (4) = 3.055,$
418 $p=0.549$). 50% of SHR families and 71.4% of LHR families reported family annual income of £42,000 or more.

419 Groups showed a significant difference in birth order distribution ($\chi^2 (4) = 20.557, p<0.001$), with the low-risk
420 group containing higher numbers of first-born children, and the SHR and LHR groups containing more third
421 or fourth children. In part, this was a function of how the groups were defined, as first-borns could not occur
422 in the SHR group, but could be classified as control/LHR depending on parental dyslexia status.

423 The children from bilingual households do not appear different in terms of SES status or background from
424 the main sample, but the number of children was too small to statistically analyse.

425 [Table 1 about here]

426 **Measures**

427 **Demographic data** were collected via questionnaire to parents for all groups, and which were completed for
428 45/51 low-risk infants, 20/23 LHR infants, 12/18 SHR infants. This questionnaire was the one included on the
429 front of the published UK-CDI measure (please see Alcock et al, 2020 for more details), and asked about
430 parental age, education and family income, as well as hours of exposure to additional languages. These
431 variables were not used for categorisation into groups, which was done solely on family risk factors as
432 described for each group below. An additional question about family history was also included. This
433 question asked parents to say whether any family member had any of the following difficulties: Hearing
434 Impairment; visual impairment; physical disability; autism spectrum disorder; Asperger Syndrome; speech
435 and language difficulties; dyslexia or other problems with reading and spelling; learning difficulties; other
436 developmental difficulties. Family history was also discussed with all parents by the first author who is a
437 qualified and experienced SLT.

438 A set of **standardised measures** was administered for validation of novel assessment tasks. These included:

- 439 • The UK Communicative Development Inventory (UK-CDI) (Alcock et al, 2020). This is a parent-report
440 measure, adapted from the MacArthur Bates Communicative Development Inventory (Fenson et al,
441 2007). Parents are given a list of 395 words across 19 categories, and asked to indicate whether their
442 child understands and/or says these words. There is also a checklist of 63 gestures and pretend play
443 actions, which parents are asked to indicate whether their child ever performs. The UK-CDI was
444 normed on 1210 children from the UK, who were selected to match the demographic composition of
445 the UK population, and may therefore represent children with a broader range of parental education
446 levels than those included in this sample. However, the UKCDI demonstrates high internal validity
447 for all scales (receptive vocabulary: $\alpha=0.99$; expressive vocabulary $\alpha=0.99$; gesture scale $\alpha=0.99$).
448 Strong correlations were also observed in the standardisation sample with scores on standardised
449 measures of language and an object selection task that measured comprehension directly (Alcock et
450 al, 2020). Parents were asked to complete the CDI for their children in English, as this was one of the
451 main languages for all families.
- 452 • The Infant Toddler Checklist (ITC) from the Communication and Symbolic Behaviour Scales –
453 Developmental Profile (CSBS-DP) (Wetherby & Prizant, 2002). This is a 24-item questionnaire,
454 completed by parents, which generates three subscale scores for Social, Speech and Symbolic
455 aspects of communication. The ITC was initially standardised on more than 2000 children in the USA,
456 many of whom were recruited from the same geographic area. However, the standardisation sample
457 matches that included in the present study in terms of having high levels of infants whose parents
458 have completed degree-level or postgraduate education. The ITC shows good levels of internal
459 consistency ($\alpha=0.93$) and test-retest reliability ($r=0.88$), as well as strong correlation in the
460 standardisation sample with other aspects of the CSBS-DP that involve more detailed parent
461 questionnaires and examiner assessment (Wetherby & Prizant, 2002). Additionally, a large cohort
462 study in Australia found the ITC to be a valid clinical tool for measuring early communication skills
463 (Eadie et al, 2010).

- 464 • The Modified Checklist for Autism in Toddlers (M-CHAT) (Robins et al, 2001). This is a 23-item
465 checklist, where parents are asked to answer “yes” or “no” to each item, based on their child’s
466 typical behaviour. A subset of 6 items of this questionnaire (the “Core 6 items”) is considered to be
467 particularly indicative of risk for a later diagnosis of ASD (Robins et al, 2001). The M-CHAT shows a
468 high level of internal consistency ($\alpha=0.85$) and also has high levels of sensitivity (0.97) and specificity
469 (0.95) (Robins et al, 2001). Although the M-CHAT is designed for use from 18 months of age, it was
470 included in this study due to its clear format and its potential for indicating emergent difficulties that
471 are linked to ASD. Scoring for this checklist is according to the number of items failed, and higher
472 scores therefore indicate more symptoms related to ASD.
- 473 • The Pre-school Language Scales, 4th Edition (PLS-4) (Zimmerman, Steiner and Pond, 2002). This is a
474 standardised language assessment, providing scores for receptive and expressive language for
475 children aged from birth to 6 years 11 months. In infancy, scores are mainly given from observation
476 of infant communication during natural interaction, although some older children in the sample
477 were administered receptive language items using toys or picture material. The PLS-4 was originally
478 standardised in the USA, on a sample of 2400 children selected to match the demographic
479 characteristics of the US population. The assessment then received additional UK standardisation
480 with a sample of 800 children matching the UK demographic profile, who were similar in ethnicity to
481 the children in this study, but had a broader range of parental education levels. Test-retest reliability
482 ($r=0.82-0.95$) and internal consistency of this measure were high ($\alpha=0.72-0.95$) in the
483 standardisation sample, and standardisation of the measure showed a good ability to distinguish
484 typically developing children from those with language disorders (Zimmerman, Steiner & Pond,
485 2002).

486

487 A set of novel **dynamic assessment** measures, designed and piloted by the authors for use in this study, was
488 also administered to the children. These measured skills in five areas found in previous studies, to be
489 associated with early communication skills including:

- 490 • Receptive vocabulary
- 491 • Motor imitation
- 492 • Response to joint attention
- 493 • Turn taking
- 494 • Requesting

495 These areas of development were chosen as representing core elements of early communication derived
496 from a number of sources including existing reviews (e.g., Ramos-Cabo et al, 2019) and a review of the early
497 communication literature (Spicer-Cain, 2019). These tasks were then tested in a feasibility phase involving 8
498 children aged 9-17 months (all monolingual; 6 white and 2 mixed ethnicity), and were judged to be engaging
499 for the children, that children were able to complete the assessment and that parents found them
500 acceptable. We concluded that the tasks formed an appropriate assessment for this age range and were
501 likely to be predictors of later language (Spicer-Cain, 2019). This feasibility pilot also helped to guide scoring
502 and number of trials on each task. Note that although early expressive language may be an important
503 predictor, because of the very young target age of the children (12 months), a dynamic cueing hierarchy for
504 this skill was not considered feasible. We therefore acknowledge that this set of DA tasks is preliminary and
505 serves as a 'proof of concept' battery to determine whether initial reliability and feasibility can be achieved.

506
507 Based on the principles of DA, graded cueing hierarchies were devised to support children to achieve each of
508 the tasks (Orellana et al, 2019). These are detailed for each task in more detail below, but overall were
509 designed to provide three prompts if the child could not achieve the task independently. Generally, the first
510 of these prompts was a repetition of the instruction, designed to draw the child's attention to the task and
511 give the child more processing time. The second prompt was more specific, and aimed to reduce the
512 difficulty of the target task. The third prompt provided full support for the child to achieve the task.

513 Administration of all DA tasks was videorecorded for reliability checking.

514

515

516 *DA of receptive vocabulary*

517 For the dynamic receptive vocabulary task, children were shown a series of five common items, which were
518 taken out of a bag and placed in front of the child, without naming them. The items (cup, car, duck, ball and
519 spoon) were chosen to represent words a child would typically acquire as part of their early vocabulary. For
520 each of the five items, the child's attention was drawn using their name, and pointing to the array of items.
521 The child was then asked to give one of the items to the researcher, accompanied by an open-hand gestural
522 prompt. The cueing hierarchy in Appendix 1 was then used for each item. Items were returned to the array
523 after each had been tested, so that the child was always looking at a choice of five items.

524

525 *DA of motor imitation*

526 Motor imitation was tested via imitation of actions on objects using a toy cup and spoon. The list of gestures
527 included in the Actions and Gestures section of the UCKDI (Alcock et al, 2020) was reviewed, and used to
528 choose these objects for use in the motor imitation task, considering previous research showing that young
529 children are more likely to imitation actions involving objects (Kim et al, 2015). Actions were then chosen
530 that could be performed with these objects, but which were mostly unrelated to their typical use, to enable
531 the experimenter to be sure whether the infant was truly imitating the action, as opposed to just showing
532 understanding of object function. A cup and spoon were given to the child at the start of the activity, and
533 the experimenter then demonstrated the action using their own set of objects, and encouraged the child to
534 copy using the phrases "X do it" and "your turn". Animated sound effects were also used by the
535 experimenter to maintain the child's attention, although the child was not required to copy the sound, and
536 most did not attempt to do so. The actions used were:

- 537 • Pretending to eat from the cup using the spoon
- 538 • Banging the spoon on the bottom of the cup
- 539 • Touching the spoon to the experimenter's nose
- 540 • Placing the cup upside down on the experimenter's head
- 541 • Stroking the spoon on the experimenter's arm

542 Allowances were made for the children’s level of motor development, and any clear attempt to perform the
543 target action was considered as correct, with no requirement for completely correct execution. The child
544 was also credited for using either their own set of items or those of the experimenter, or for performing the
545 actions on their own body or the experimenter’s. For each of the five items, the cueing hierarchy in
546 Appendix 1 was used.

547

548 *DA of response to joint attention (point following)*

549 Response to joint attention (RJA) was assessed based on the child’s ability to follow adult pointing, during a
550 picture-book reading task. A first words picture book containing large colourful photographs of everyday
551 objects was used, with several objects pictured on each page. Unlike the other subtests, ten trials were run
552 for this task, because the pilot study suggested both that infants at this age were more difficult to score on
553 this item; and that increased items on this task were better tolerated than for other DA items (ideally all
554 elements would have run with ten trials). For each RJA trial, the experimenter pointed at an item on the
555 page, saying “Look! A (name of item)”. To aid the scoring of the task, the items used for each child were
556 chosen so that the child would have to make an obvious gaze shift from where they were currently looking
557 to look at the item to which the adult was pointing. The sequence of cueing in Appendix 1 was used. If the
558 child pointed to items in the book, the experimenter named these, and the child was allowed to look at each
559 page until they lost interest, although only one trial was made on each page.

560

561 *DA of turn-taking*

562 Turn-taking skills were assessed using a ball-run toy designed for infants, where a ball is put into a hole and
563 then runs down a spiral track. The experimenter first demonstrated the toy for the child by taking a turn, and
564 then encouraged the child to take a turn using the phrase “X’s turn”/ “you do it”. Once the child was
565 engaged with the toy, the experimenter initiated a turn-taking sequence by taking a turn themselves (see
566 Appendix 1). Five turn sequences were then scored according to the procedure in Appendix 1. The

567 experimenter and child then continued to play with the toy until the child lost interest, although only the
568 first five turns were scored.

569

570 *DA of social requesting*

571 Requesting was measured using a disco ball, which spun and displayed colourful lights when it was switched
572 on. The child was shown the toy, and once they were engaged with it, the toy was then switched off.

573 Appendix 1 shows the cueing sequence which was then used to support the child to make a request to have
574 the toy turned back on. Requests did not have to be verbal, and could be made using gesture, touch or
575 vocalisation, as long as this was considered to be socially referenced (accompanied by eye contact to the
576 experimenter or parent). Five trials were scored, and then the experimenter and the child continued to play
577 with the toy until the child lost interest in it.

578

579 ***Procedure***

580 Children were assessed by the first author who is a qualified SLT, in their home with a parent present. For
581 the first fifteen minutes of the session, parents and children were video recorded playing with a standard set
582 of toys. During this time, aspects of the PLS-4 which could be rated from observation were completed. The
583 remainder of the appropriate items from the PLS-4 were administered, depending on the age and abilities of
584 the child. The dynamic assessment measures were then administered and scored live during task
585 completion. However, all tasks were videorecorded for later reliability checking. The total duration of the
586 session was around 60 minutes for each child. This included DA administration and scoring of between 10 to
587 25 minutes. Parents were then given a set of questionnaires to complete and return to the research team,
588 including the three standardised questionnaire measures listed above.

589

590

591

592

593 **Analysis**

594 Results were analysed using SPSS version 23.

595 For research question 1, intraclass correlations were used to assess reliability. Cronbach's alpha was used to
596 report internal consistency.

597

598 For research question 2, due to the non-normal distribution of some variables, Spearman correlations were
599 used to investigate the relationship between age and scores on each of the dynamic assessment measures.

600 As age was significantly related to most scores, partial correlations were used to establish relationships
601 between dynamic assessment scores and scores on other measures taken concurrently. Mann-Whitney U
602 tests were used to compare scores across biological sex.

603

604 For research question 3, ANCOVAs were used to compare all 3 groups on the DA tasks, controlling for age.

605 Assumptions of ANCOVA were checked: Homoscedasticity was verified via scatterplots of predicted against
606 standardised residuals, and there were no outliers for any task. However, Shapiro Wilks tests showed that
607 standardised residuals were significantly non-normally distributed in at least one group for all tasks.

608 Transformation of data did not normalise the distributions. No difference in the pattern of results was
609 observed when combining both high-risk groups and comparing to low-risk groups, thus this analysis is not
610 reported. There was not enough variability in maternal education scores to consider this as a covariate.

611

612 No results changed substantively on any analysis when children from bilingual families (n=7) were removed,
613 therefore all children are retained in the analyses that follow.

614

615

616

617

618

619 **Results**

620 *Descriptive Statistics*

621 Descriptive statistics for the five DA measures for the children in the low-risk control group only are reported
622 in Table 2. This group of children act as a normative sample and thus are the basis for the development of
623 the tool. Adjusted means from all groups are reported later when we compare scores across known groups.
624 Scores on all measures were not normally distributed, with floor effects present on the measures of
625 receptive language, motor imitation and turn taking, and ceiling effects present on the measures of response
626 to joint attention and social requesting. Interquartile ranges are reasonably wide across all tasks.

627

628 [Table 2 about here]

629

630 ***Aim1: Reliability of the DA tasks***

631 *Inter-rater Reliability*

632 In order to ensure the reliability of the above scores, a random subset of 27 videos, selected using stratified
633 sampling to represent 25% of each risk group, was scored by a second rater to investigate inter-rater
634 reliability for the dynamic assessment measures. The independent rater was given the DA scoring
635 hierarchies, training in the scoring methods used, and the basic information about the project was explained,
636 but they were not told any other information about the children, and so were blind to group status or other
637 scores. Intra-class correlation coefficients for the dynamic assessment measures represent 'good' (>0.75) or
638 'excellent' (>0.90) agreement for all dynamic assessment measures except Turn Taking which was moderate
639 at 0.70 (Koo & Li, 2016) when the whole sample was considered. All values were good or excellent for our
640 normative (low-risk) and SHR samples. All values except turn-taking were in this range for the LHR group
641 (see Table 3).

642 [Table 3 about here]

643

644

645 *Inter-task correlations and internal consistency*

646 With the effect of age statistically controlled, the five DA measures did not show significant partial
647 correlations with one another, suggesting that they should not be combined into a single scale (see Table 4).
648 Unsurprisingly, internal consistency of the battery was therefore low at $\alpha = 0.594$.

649

650 [Table 4 about here]

651

652 ***Aim 2: Relationship of DA tasks with age and standardised measures of communication***

653 *Relationship with Age*

654 There were significant positive relationships between age and all but one of the DA tasks. For Receptive
655 Language ($r = .553, p < .001$), Motor Imitation ($r = .640, p < .001$) and Turn-taking ($r = .777, p < .001$) these
656 associations were all strong, whilst for Response to Joint Attention the relationship was moderate ($r = .495, p$
657 $< .001$). There was no age relationship with the DA of Requesting ($r = -.072, p = .620$), with high variability of
658 scores present at all ages. Fig 1 illustrates the findings.

659

660 [Fig 1 about here]

661

662 *Relationship with Sex*

663 Due to the non-normal distribution of scores on the DA measures, Mann-Whitney U tests were used to
664 compare the scores of boys and girls from the low-risk control group on the five tasks. None of the
665 comparisons showed significant differences, although there was a marginal difference on the motor
666 imitation task in favour of girls (see Table 5).

667

668 [Table 5 about here]

669

670

671 *Relationships with Other Measures*

672 Scores on the DA tasks were compared with scores on other parent-reported and experimenter-
673 administered standardised measures of communication ability. Three DA tasks showed moderate to large
674 associations with at least one other measure taken concurrently. For the DA receptive language task,
675 significant correlations were found with parent-reported receptive vocabulary on the UKCDI, and with
676 receptive and expressive language scores on the PLS-4. The ITC Symbolic and Social subscale scores showed
677 a significant association with the DA turn taking task, which was also significantly correlated with Total
678 Gestures scores on the UKCDI. For the DA social requesting task, significant correlations were found with
679 parent-reported expressive vocabulary on the UKCDI, and the ITC Social subscale (see Table 6).

680

681 After correcting for multiple comparisons using the Bonferroni method, only the association between the DA
682 measure of receptive language and the PLS-4 Auditory Comprehension score remained significant.

683

684 [Table 6 about here]

685

686 ***Aim 3: Comparison of DA tasks across low-risk and high-risk groups*** One-way between-groups ANCOVAs
687 with age entered as a covariate were run to evaluate group differences on the DA measures. Adjusted mean
688 scores for each group on all tasks can be seen in Table 7.

689

690 [Table 7 about here]

691

692 *Receptive Language*

693 Age was significantly related to scores on the DA of receptive language within the ANCOVA model ($F(1, 88) =$
694 $73.669, p < .001$). Significant group differences were found on the dynamic receptive language task ($F(2, 88)$

695 = 5.218, $p = .007$, $\eta^2_p = 0.106$)³. Scores in the SHR group were significantly lower than those of the low-risk
696 group ($p = .002$) and the LHR group ($p = .016$). Scores in the LHR group did not differ from the low-risk group
697 ($p = .558$). See Table 7 for adjusted means and SEs.

698

699 *Motor Imitation*

700 The association between age and motor imitation scores was significant within the ANCOVA model ($F(1, 88)$
701 = 53.021, $p < .001$). Scores on the DA of motor imitation did not differ significantly between groups ($F(2, 88)$
702 = 1.212, $p = .302$, $\eta^2_p = 0.027$), although the mean score of the SHR group was lower than those of the other
703 two groups.

704

705 *Response to Joint Attention*

706 The covariate age was significantly related to scores on the DA of response to joint attention within the
707 ANCOVA model ($F(1, 88) = 15.997$, $p < .001$). The ANCOVA did not indicate significant differences between
708 risk groups for response to joint attention scores ($F(2, 88) = 0.511$, $p = .602$, $\eta^2_p = 0.011$), although the mean
709 score of the SHR group was lower than for the low-risk and LHR groups.

710

711 *Turn-taking*

712 Age was significantly related to score on the DA of turn taking within the ANCOVA model ($F(1, 87) = 42.582$,
713 $p < .001$). Turn taking scores showed no significant differences among risk groups ($F(2, 87) = 0.461$, $p = .633$,
714 $\eta^2_p = 0.010$), although the mean scores in both high-risk groups were lower than for the low-risk group.

715

716

717

718

³ Notably the UK-CDI receptive vocabulary scale (Alcock et al, 2017) was not sensitive enough to detect differences across these groups ($F(2, 74) = 2.114$, $p = .128$, $\eta^2_p = 0.054$).

719 *Social requesting*

720 Age did not show significant relationship to scores on the DA of social requesting within the ANCOVA model
721 ($F(1, 86) = 2.879, p = .093$) and neither did the ANCOVA show significant group differences in scores on the
722 dynamic requesting task ($F(2, 86) = 1.028, p = .362, \eta^2_p = 0.023$).

723

724 This pattern of results was identical when combining the two high risk groups in comparison to the low-risk
725 infants.

726

727 **Discussion**

728 The current study aimed to present 'proof of concept' findings from a set of new dynamic tasks of early
729 communication for infants, with the long term aim of developing a tool that can be used reliably and easily
730 within family homes. This study is unique in using DA to investigate the skills of infants at high risk of
731 communication difficulties. The tasks presented here are a first step towards more reliable communication
732 assessment of children at very early ages before most static measures are appropriate.

733

734 ***Task characteristics***

735 While the five tasks showed only weak inter-correlations and therefore appear to be measuring different
736 constructs, each measure had good inter-rater reliability (across all groups). In addition, four of the five DA
737 tasks showed a significant correlation with age, indicating sensitivity to developing abilities in children within
738 the age range studied here. However, the fact that there were some floor and ceiling effects, indicates that
739 the tasks may need to be refined to capture a fuller range of language and communicative potential in both
740 clinical and typically developing populations. This would eventually enable the creation of norms so that
741 individual child scores on each task can be interpreted appropriately on a clinical basis according to age. No
742 sex differences were observed in our normative sample, suggesting that DA might in the future serve as a
743 useful tool for equality of diagnosis across boys and girls.

744

745 The tasks also showed significant correlations with standardised measures for our normative, low-risk
746 sample, suggesting that they are valid and are tapping important constructs relevant to communication. Our
747 DA tasks were also sensitive enough to detect some early differences between risk groups, especially for
748 receptive language, which was the only task out of the five to show statistically significant differences. The
749 SHR group also received lower mean scores than low-risk infants on the motor imitation, point following and
750 turn taking tasks, but these did not constitute significant differences. No differences were found between
751 LHR children and the children in the low-risk group. These findings are now discussed in more detail below.

752

753 ***Receptive language and other group comparisons***

754 Receptive language was the only task to show significant differences across groups. Nevertheless, at this
755 early stage of test development, the trend towards lower scores for children in the SHR group for turn
756 taking, RJA and motor imitation (which all relate to the development of receptive language), is also worth
757 noting and taking forward to the next iteration. Receptive language was also the only DA task to correlate
758 with standardised tasks. This result in itself does not entirely limit the usefulness of the other DA tasks, since
759 it may be that they are more sensitive than standardised tests at this age, or that they are measuring slightly
760 different aspects of communication. However, taken together, our results highlight receptive language as
761 the most promising early assessment domain, especially for children at risk of autism. This is particularly
762 interesting given that receptive language has been found to be a strong predictor of language outcome both
763 for children with autism and for late talkers (Brignall et al, 2019; Fisher, 2017).

764

765 We were somewhat surprised that the LHR group showed no differences compared to the low-risk group.
766 This may be due to the group criteria including family members with dyslexia, which is diagnosed later, or
767 because the pathway of difficulties for those with language disorders is more gradual and less identifiable in
768 infancy. Notably receptive language was not different for the LHR group whereas this was already showing
769 signs of impact for the SHR group. Several research studies have demonstrated the instability between early
770 language delay and later language impairment (e.g. Dale et al, 2003; Reilly et al, 2010; Zambrana et al, 2014;

771 Duff et al, 2015; Rudolph et al, 2016). It may be the case that group differences based on *family history* were
772 not evident here, but that individual children who later receive diagnoses of communication difficulties will
773 show differences on the DA tasks as infants, indicating their predictive validity. The crucial aspect in
774 validating these DA tasks is whether they can be used to identify children who require support early on.
775 Work is ongoing to follow up the current cohort at school age to investigate this very question.

776

777 ***Strengths and limitations of the present study***

778 The present study addressed a number of key gaps in the literature. Firstly, studies of language high-risk
779 children are few, while numerous studies of social-high-risk children exist. Although few differences were
780 evident between LHR and low-risk children, it may be that these will manifest later in childhood, particularly
781 in terms of literacy outcomes (e.g., Zambrana et al. 2014). Secondly, this study is one of only a few studies to
782 use DA methods to assess infants, particularly infants at high risk of communication disorders.

783

784 *Age of the children*

785 In order to recruit a sufficient sample, the age range of the children was wider than ideal. Our key aim for
786 developing the tool was to keep the age range of the *low-risk children* reasonably tight and this was
787 achieved, with only 3 of this group older than 16 months. However, the age range of the social high-risk
788 group was wider. As with most clinical measures, we anticipate that a tool of this kind may be useful for
789 identifying older children who are at risk of language and communication difficulties, and who are
790 functioning at a lower level than expected for age. Attempts were made to control for age effects in
791 statistical analyses, but it is acknowledged that results would be clearer and easier to interpret in a cohort
792 that had a narrower age range at each assessment time point. There is also a suggestion in existing research
793 that the profiles of children with language difficulties change with age, such that social communication
794 difficulties and features relevant to ASD diagnosis become more prominent over time in children whose
795 language difficulties appeared more specific earlier in childhood (e.g., Conti-Ramsden et al, 2006 Chiat &
796 Roy, 2013; Charman et al, 2015). Replication of similar results in a sample with higher proportions of high-

797 risk children, and with follow-up of the sample at later ages, would lend weight to the conclusions of this
798 study, and would allow analysis of some trends that did not reach significance in the current sample, but
799 appeared to have large effect size.

800

801 *Sample diversity*

802 In addition, the self-selecting nature of the sample means that results are not necessarily generalisable to
803 the total population of young children. The parents who responded to recruitment advertising were typically
804 educated at degree level or higher, were older than 30, and had higher levels of family income than the
805 population as a whole. Their children may therefore not accurately represent children from a broader range
806 of socio-economic status. It would therefore be useful to recruit a sample of participants more diverse in
807 socio-economic factors such as family income and parental education, to assess whether this affects the
808 pattern of results. Although 7 children came from bilingual families, removing them from analyses did not
809 affect results. However, it was not possible to statistically compare children exposed to other languages to
810 those in monolingual households due to small numbers. Increasing the diversity of the sample would be an
811 important step for future research as this would help to establish the utility of culturally-sensitive
812 assessments. For the purposes of this study the only language tested was English, but we acknowledge that
813 in clinical practice, all home languages should be assessed. One of the potential strengths of DA is that tests
814 may be more easily adapted to work across several languages.

815

816 It is also the case that parents who already had concerns about the development of their child may have
817 been more likely to enrol them to participate in this research project, so that their communication
818 development could be evaluated. It is therefore possible that the groups of high-risk children who
819 participated in the study contain higher numbers of children with developmental communication difficulties
820 than would be the case in an unselected sample, although our results suggest this is not the case. Indeed,
821 the opposite may also be true, in that parents with concerns about their second child might have avoided a
822 study where issues could have been revealed.

823 *Measurement issues*

824 Another potential limitation was that some of the siblings were too young to complete the CCC-2 (although
825 we introduced alternative criteria for these few) and some parents did not return sibling questionnaires.
826 Furthermore, there was also no direct assessment of sibling/parent probands with communication or
827 literacy difficulties and classification of children was dependent on parental reports. Together, these
828 limitations reveal that establishing sibling status is not a straightforward process. In future research, more
829 objective classification using direct measures of parent and elder sibling language, social communication and
830 literacy skills could be of benefit.

831

832 The range of measures taken in this study allowed evaluation across many areas of development, and also
833 allowed the comparison of novel tasks with established measures for a normative sample. However, it is
834 important to note that the assessments were not blinded, as the first author and assessor had knowledge of
835 the children's risk status. Nevertheless, good inter-rater reliability was achieved for novel tasks after coding
836 by researchers who were blind to the children's group status. We did not include a DA of expressive
837 vocabulary. This is because we felt it would be difficult to define a cuing hierarchy with children who were
838 mostly non-verbal, but assessment of utterances or vocalisations could be explored in further studies.

839

840 Finally, the fact that there was only one task per skill may also serve to limit the assessment battery. It
841 should be noted however, that infants are very restricted in terms of the time and attention they can apply
842 to formal tasks. Indeed, we originally intended all DA items to have 10 trials, but our feasibility pilot
843 suggested that only RJA was tolerated sufficiently for this number. The DA tasks presented here are being
844 developed with a view to offering a quick yet reliable addition to tools used by health visitors and other
845 infant-care professionals.

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849 ***Future directions and Dynamic Assessment in practice***

850 Some adaptations could be useful in future versions of our tasks. In particular, it may be beneficial to
851 combine some of the tasks into one composite subtask tapping into early non-verbal communication skills.
852 The receptive vocabulary task could also be modified to incorporate novel word learning opportunities; an
853 expressive task could be included for older children; and the scoring of tasks could be standardised across
854 areas. Other aspects of communication which are emerging, and may be more easily measurable than
855 vocabulary (such as vocalizations), might also be useful target behaviours to include as part of a DA of early
856 communication. Thus, further development of the DA tasks should be a focus of future research, including
857 data from large diverse samples, trials for additional items and more detailed investigations into reliability
858 and validity of the measures especially at an individual level. Ultimately, if key tasks differentiating children
859 at high risk of later language delay and/or social communication difficulties could be identified through
860 further studies, it would be possible to trial intervention programmes for children who show early signs of
861 these difficulties and evaluate the effect on outcomes. It may be that the children in our high-risk groups do
862 not go on to develop communication disorders, despite their family histories and conversely, some children
863 in the low-risk group may develop a communication disorder. Therefore, the utility and inter-rater reliability
864 established for the DA tasks in the current study warrant future work on developing and formalising these
865 tasks in order to improve the prediction of future difficulties.

866

867 In spite of the need for further development of these procedures, we concur with Hasson & Joffe (2007), in
868 believing that dynamic approaches are a promising way forward for providing practitioners with a reliable
869 user-friendly screening tool for identifying infants at risk. DA tasks have the advantage of being a quick to
870 administer direct assessment that is infant-friendly and ecologically valid in contrast to existing standardised
871 tools that are often used inappropriately (Dockrell & Marshall, 2015; Cycyk et al, 2021; Spaulding, Plante &
872 Farinella, 2006; Betz et al, 2013). We have shown that they can also be carried out with reliability. However,
873 further work is needed to establish clinical discrimination between individual children who will need
874 language and social support, and those who do not (Szatmari et al. 2016).

875

876 Lastly, for DA to be used in practice, the issue of training would need developing and evaluating at an
877 individual case level. In the present study, all assessments were completed by the same Speech and
878 Language Therapist (SLT; first author), but in practice any infant assessments would ideally be available to a
879 wider group of professionals such as health visitors following full test development. Continuing work
880 suggests that this training would be much easier and quicker than for most DAs, but rigorous further
881 development of the tool is needed before any clinical implementation.

882

883 ***Conclusions and implications***

884 This study suggests that Dynamic Assessment for infants may be feasible and useful, especially in the domain
885 of receptive language. Many children with communication disorders are still being identified too late to
886 access the critical early intervention they need, and appropriate standardised tests are not currently
887 available. Although we have focussed here on children at risk of Autism and DLD, our hope for the long term
888 is that tools can be developed to identify communication issues in a wide range of children.

889 We acknowledge that there are numerous barriers to early identification, especially in the UK. However, if
890 parents and professionals were to have a reliable screening tool to identify the key markers of
891 communication disorders in early life, this may increase the number of children identified before the age of
892 two or three. This would in turn allow more children to access intervention designed to improve outcomes.
893 This work represents just the first steps towards such a tool. Further longitudinal work will play a key part in
894 determining which skills in infancy are predictive of communication problems not just at preschool age, but
895 into the school years and adolescence. Only then can children receive earlier intervention and thereby attain
896 more positive academic and psychosocial outcomes later in life.

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900

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904 resulting from this project.

905

906 **Data Availability Statement**

907 The data produced by this study is preliminary and therefore is not hosted on an open access platform.

908 However, data requests can be made to the first or corresponding author.

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1307 *Table 1: Demographic information for the whole sample by group*

	Whole Sample (n=92)	Low-risk Group (n=51)	SHR Group (n=18)	LHR Group (n=23)
Child Age (mean/SD)	13.1(3.4)	12.2 (3.0)	15.4 (3.9)	13.2(3.0)
Child Sex				
Male	42 (45.6%)	26 (51.0%)	8 (44.4%)	8 (34.8%)
Female	50 (54.4%)	25 (49.0%)	10 (55.6%)	15 (65.2%)
Birth order				
1	40 (43.5%)	30 (58.8%)	0 (0%)	10 (43.5%)
2	36 (39.1%)	16 (31.4%)	12 (66.7%)	8 (34.8%)
3 or higher	16 (17.4%)	5 (9.8%)	6 (33.3%)	5 (21.7%)
Maternal Age				
25 or younger	2 (2.6%)	2 (4.7%)	0 (0%)	0 (0%)
26-30	11 (14.3%)	7 (16.3%)	1 (8.3%)	3 (13.6%)
31-35	39 (50.6%)	21 (48.8%)	6 (50.0%)	12 (54.5%)
36 or older	25 (32.5%)	13 (30.2%)	5 (41.7%)	7 (31.8%)
Paternal Age				
25 or younger	1 (1.3%)	1 (2.3%)	0 (0%)	0 (0%)
26-30	11 (14.1%)	7 (15.9%)	2 (16.7%)	2 (9.1%)
31-35	26 (33.3%)	14 (31.8%)	5 (41.7%)	7 (31.9%)
36 or older	40 (51.3%)	22 (50.0%)	5 (41.7%)	13 (59.1%)
Maternal Education				
No formal qualifications	1 (1.3%)	0 (0%)	0 (0%)	1 (4.5%)
Level 2 (GCSE or equivalent)	2 (2.6%)	0 (0%)	2 (16.7%)	0 (0%)
Level 3 (A-Level or equivalent)	4 (5.1%)	2 (4.5%)	2 (16.7%)	0 (0%)
Degree or equivalent	30 (38.5%)	20 (45.5%)	2 (16.7%)	8 (36.4%)
Postgraduate Qualification	41 (52.6%)	22 (50.0%)	6 (50.0%)	13 (59.1%)
Paternal Education				
No formal qualifications	1 (1.3%)	0 (0%)	0 (0%)	1 (4.5%)
Level 2 (GCSE or equivalent)	8 (10.3%)	3 (6.8%)	2 (16.7%)	3 (13.6%)
Level 3 (A-Level or equivalent)	9 (11.5%)	3 (6.8%)	3 (25.0%)	3 (13.6%)
Degree or equivalent	29 (37.2%)	20 (45.5%)	4 (33.3%)	5 (22.7%)
Postgraduate Qualification	31 (39.7%)	18 (40.9%)	3 (25.0%)	10 (45.5%)
Family Income				
£14,000 or less	3 (3.9%)	1 (2.3%)	1 (8.3%)	1 (4.8%)
£14,001 to £24,000	4 (5.3%)	1 (2.3%)	2 (16.7%)	1(4.8%)
£24,001 to £42,000	15 (19.7%)	8 (18.6%)	3 (25.0%)	4 (19.0%)
£42,001 or more	54 (71.1%)	33 (76.7%)	6 (50.0%)	15 (71.4%)

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1310 *Table 2: Descriptive information on DA tasks for low-risk infants*

Measure	Range of Scores	Mean (SD)	Median (IQR)
Receptive Language	0-15	4.02 (4.54)	2.0 (1-7)
Motor Imitation	0-15	4.38 (4.11)	3.5 (1-6.5)
Response to Joint Attention	0-30	19.54 (9.44)	23.0 (11.75-27)
Turn Taking	0-15	2.86 (3.79)	1.0 (0-5.25)
Social Requesting	0-15	10.0 (4.59)	12.0 (76.75-14)

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1333 *Table 3: Inter-rater reliability for each DA task for the whole sample and by group*

Measure	Whole Sample ICC	Low-Risk ICC	SHR ICC	LHR ICC
Receptive Language	.902	.886	.966	.820
Motor Imitation	.869	.799	.918	.895
Response to Joint Attention	.958	.929	.977	.972
Turn Taking	.702	.815	.828	.386
Social Requesting	.852	.750	.971	.838

1334 **ICC of 0.75-0.9 is considered 'good' whilst 0.9 and above is considered excellent.*

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1354 *Table 4: Correlations between DA subtests for the low-risk group*

	DA Receptive Language	DA Motor Imitation	DA Response to Joint attention	DA Turn Taking
DA Motor Imitation	$r = .210$ $p = .182$			
DA Response to Joint Attention	$r = .240$ $p = .126$	$r = -.025$ $p = .875$		
DA Turn Taking	$r = .009$ $p = .954$	$r = -.108$ $p = .496$	$r = .140$ $p = .377$	
DA Social Requesting	$r = .115$ $p = .467$	$r = .053$ $p = .739$	$r = -.003$ $p = .986$	$r = -.090$ $p = .570$

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1372 *Table 5: Mann Whitney statistics for sex comparisons on DA tasks in the low-risk group*

	Mann-Whitney <i>U</i>	<i>P</i> value	1373
	statistic		1374
Receptive Language	282.5	.449	1375
Motor Imitation	231.5	.085	1376
Response to Joint Attention	307.0	.776	1377
Turn-Taking	250.5	.155	1378
Social Requesting	292.5	.761	1379
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Table 6: Relationships between DA tasks and standardised tests for the low-risk group

	DA Receptive Language	DA Motor Imitation	DA Response to Joint Attention	DA Turn Taking	DA Social Requesting
UKCDI Receptive Vocabulary	$r = .389$ $p = .011$	$r = .182$ $p = .249$	$r = .258$ $p = .100$	$r = .071$ $p = .653$	$r = .144$ $p = .362$
UKCDI Expressive Vocabulary	$r = .154$ $p = .331$	$r = .169$ $p = .285$	$r = -.080,$ $p = .617$	$r = -.285,$ $p = .067$	$r = .404$ $p = .008$
UKCDI Total Gestures	$r = .209$ $p = .183$	$r = -.164$ $p = .301$	$r = .154$ $p = .332$	$r = .315$ $p = .042$	$r = -.272$ $p = .082$
ITC Social Subscale	$r = .157$ $p = .321$	$r = .021$ $p = .895$	$r = .081$ $p = .610$	$r = .389$ $p = .011$	$r = -.307,$ $p = .048$
ITC Speech Subscale	$r = .223$ $p = .156$	$r = -.066$ $p = .677$	$r = -.083$ $p = .601$	$r = .083$ $p = .599$	$r = -.040$ $p = .802$
ITC Symbolic Subscale	$r = .102$ $p = .522$	$r = -.098$ $p = .536$	$r = .255,$ $p = .102$	$r = .355$ $p = .021$	$r = -.139$ $p = .380$
M-CHAT Core-6 Items Failed	$r = -.074$ $p = .641$	$r = -.125$ $p = .431$	$r = .050$ $p = .754$	$r = -.257$ $p = .101$	$r = .272$ $p = .081$
PLS-4 Auditory Comprehension Score	$r = .477$ $p = .001^{**}$	$r = .184$ $p = .244$	$r = .221$ $p = .159$	$r = .252$ $p = .107$	$r = -.069$ $p = .665$
PLS-4 Expressive Communication Score	$r = .353$ $p = .022$	$r = .246$ $p = .117$	$r = -.056$ $p = .723$	$r = .039$ $p = .806$	$r = -.133$ $p = .400$

Bold type indicates significant relations

****This relationship remains significant after adjusting for multiple comparisons using the Bonferroni method.**

1408 *Table 7: Adjusted mean scores and standard errors for each group on DA tasks*

Group	Adjusted Mean Score	Standard Error	Significant differences
Receptive Language			
Low-risk	4.87	0.49	SHR<LHR=LR
SHR	1.62	0.86	
LHR	4.36	0.72	
Motor Imitation			
Low-risk	5.13	0.46	No differences across groups
SHR	3.65	0.80	
LHR	4.86	0.67	
Response to joint attention			
Low-risk	20.36	1.19	No differences across groups
SHR	17.94	2.07	
LHR	20.17	1.74	
Turn taking			
Low-risk	3.50	0.45	No differences across groups
SHR	2.72	0.78	
LHR	2.94	0.67	
Social requesting			
Low-risk	9.80	0.64	No differences across groups
SHR	10.42	1.10	
LHR	11.43	0.94	

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1419 *Fig 1: DA task correlations with age for the low-risk group (separate file)*

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1453 **Appendix 1: Cueing and Scoring for the DA tasks**

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1455 *Receptive Language*

The array of items was indicated and the child asked "Give me the..."	Correct response – score 3
If the child made no response, or selected the wrong item, the wrong item was returned to the array and the instruction repeated.	Correct response after repetition – score 2
If the child made no response, or selected the wrong item, three of the items were removed from the array, leaving a choice of two, and the instruction was repeated.	Correct response from choice of 2 – score 1
If the child still made no response or selected the wrong item, the correct item was indicated and the child told "Here is the...". The child was then praised.	Incorrect response after prompting – score 0

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1458 *Motor Imitation*

Modelling of action, preceded by "Look what I can do!" and followed by the command "X do it..."	Copying of action following model – score 3
If no response was made, the action and the command "X do it... was repeated"	Copying of action with extra verbal prompt – score 2
If the action was not copied, or the child performed another action, the action was repeated, exaggerating the action.	Copying of action after repetition – score 1
If the action was not copied following this, the child was praised and the next item presented.	No attempt to copy or another action produced – score 0

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1466 *Joint Attention*

The experimenter pointed at an item on the page and said "Look! A..."	Gaze shift to focus of pointing – score 3
If the child did not response to this, the instruction was repeated using the child's name.	Gaze shift following repetition – score 2
If the child still did not shift their gaze, a light touch was used to gain their attention and direct them to the page, with the instruction "look!"	Gaze shift following physical prompt – score 1
If the child still did not attend to the focus of pointing, the next item was presented.	No gaze shift after cueing – score 0

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1470 *Turn Taking*

Experimenter handed ball to child following child's turn	Child spontaneously stops and waits for experimenter to take a turn - score 3
If the child moved their ball towards the run without waiting for the experimenter to take a turn, the verbal prompt "My turn" was used	Child stops and waits for experimenter to take a turn following verbal prompt - score 2
If the child did not respond to the verbal prompt, a physical prompt of blocking the child's entry to the run was used, along with a repetition of "My turn"	Child stops and waits for experimenter to take a turn following a physical prompt - score 1
If the child persisted in taking their turn, the experimenter then allowed this, and began the procedure again for the next trial	Child does not stop and wait for experimenter's turn despite physical prompting - score 0

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1477 *Social Requesting*

<p>The experimenter turned off the toy and waited for a response.</p>	<p>Child spontaneously bids for the toy to be turned back on – score 3</p>
<p>If the child made no response, the verbal prompt “Would you like more?” was used.</p>	<p>Child bids for toy to be turned back on after verbal prompt – score 2</p>
<p>If the child still made no response, a light touch was used to call their attention to the toy and the verbal prompt was repeated.</p>	<p>Child bids for toy to be turned back on after verbal and physical prompt – score 1</p>
<p>If the child still made no response, the toy was turned back on, with the word “More” and the procedure was repeated.</p>	<p>No bid for help – score 0</p>

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