The role of joint engagement in the development of language in a community-derived sample of slow-to-talk children

Journal:	*Journal of Child Language*
Manuscript ID	JCL-12-16-145.R3
Manuscript Type:	Article
Keywords:	Joint engagement, mother-child interaction, Attention

Title: The role of joint engagement in the development of language in a community-derived sample of slow-to-talk children

Running head: Joint engagement and language development

Abstract

We explored whether supported (SJE) or coordinated joint engagement (CJE) between mothers recruited from the community and their 24-month-old children who were slow-to-talk at 18-months-old were associated with child language scores at ages 24-, 36- and 48-months (n=197). Further, whether SJE or CJE modified the concurrent positive associations between maternal responsive behaviours and language scores. Previous research has shown that SJE, maternal expansions, imitations and responsive questions were associated with better language scores. Our main finding was that SJE but not CJE was consistently positively associated with 24- and 36-month-old expressive and receptive language scores, but not with 48-month-old language scores. SJE modified how expansions and imitations, but not responsive questions, were associated with language scores; the associations were evident in all but the highest levels of SJE. Further research is necessary to test these findings in other samples before clinical recommendations can be made.

Key words: joint engagement, mother-child interaction, attention, responsivity

Background

Maternal responsive behaviours used during joint engagement (JE) with their young children predict better language skills (Levickis, Reilly, Girolametto, Ukoumunne, & Wake, 2014). JE can vary in duration, quality, and in how the child coordinates their attention (Adamson et al., 2004, 2009). To what extent these JE variations are associated with language outcomes, and whether they modify the effect of maternal responsive behaviours on language development is unclear. Better understanding could inform early language interventions which teach parents to use these responsive behaviours. Since unresolved language difficulties are associated with poorer educational, interpersonal and psychosocial outcomes into adulthood (e.g. Beitchman et al., 2001), improving the efficacy of these interventions is important. The current paper explores the contribution of JE to expressive and receptive language learning both directly and via its effect on maternal responsive behaviours.

Research into maternal behaviours, JE and language development has tended to examine children with typically developing language and with language delay separately (e.g. D'Odorico & Jacob, 2006; Paul & Shiffer, 1991; Rescorla, Bascome, Lampard, & Feeny, 2001). This truncates the distribution of language abilities considered in each study. The present study focuses on children identified with low expressive vocabulary at an earlier age (18-months compared to 24-months) and below a more liberal vocabulary cut-point (20th compared to 10th percentile) than usual. A large proportion show language scores within the normal range at 24-, 36- and 48-months, which is useful for investigating the associations across a wide distribution of language abilities.

JE is when parent and child are actively focused on the same object or event at the same time and are aware of each other doing so (Adamson & Bakeman, 1991; Dunham and Dunham, 1995; Moore and Dunham, 1995). JE skills, for example pointing, showing and

using eye contact, are positively associated with language skills (Farrant, Devine, Maybery, & Fletcher, 2012; Kasari, Gulsrud, Freeman, Paparella, & Hellemann, 2012; Tomasello & Todd, 1983). Subsequently, JE difficulties might contribute to problems with language learning (Mundy, Kasari, Sigman, & Ruskin, 1995). Indeed, children with autism spectrum disorders and late talkers have been found to have difficulties with JE compared with typically developing children (Patterson, Elder, Gulsrud, & Kasari, 2014; Paul & Shiffer, 1991; Vuksanovic & Bjekic, 2013; Wetherby, Yonclas, & Bryan, 1989).

JE is thought to underpin language acquisition by creating a shared referential framework which helps children make the correct connection between their parent's spoken word and its referent (Akhtar, 2005; Bruner, 1975; Carpenter et al., 1998; Tomasello, 2001; Yu & Ballard, 2007). Within the JE context, children can look at the referent for enough time to learn and practise its word, approximately 1-2 seconds before and after it is spoken (Dixon & Salley, 2006; Kannass & Oakes, 2008; Trueswell et al., 2016). Hence, variations in how children coordinate their visual attention during JE may explain differences in language learning.

During 'supported' JE (SJE) children visually attend to the shared object only, whilst their parents scaffold the interaction, follow their child's interests, and maintain turns (Adamson et al., 2009). In contrast, during 'coordinated' JE (CJE) children help maintain the interaction by attending to the object and parent, usually by alternating their gaze (Adamson et al., 2009). CJE is therefore likely to tax children's cognitive and affective resources more so than SJE (Adamson et al., 2009), and to reduce the time children can look at a spoken word's referent. SJE may therefore provide a better contextual framework for word learning than CJE. Indeed, one small scale study of typically developing children (n=56) found time in SJE at 18-months-old was associated with better expressive and receptive vocabulary scores

at 30-months, but time spent in CJE was not (Adamson et al., 2004, 2009). This has yet to be tested in a larger sample or with measures of language skills beyond vocabulary knowledge.

The shared referential framework created in JE gives children the opportunity to benefit from the language-facilitating aspects of maternal responsive behaviours (e.g. Diaz et al., 1991). Seminal work by Tomasello and Farrar (1986) demonstrated that maternal verbal input used inside JE at 15-months was correlated with language abilities at 21-months, whilst input used outside of JE was not. Previous findings from the sample in the present study showed that maternal responsive behaviours (expansions, imitations and responsive questions) used during JE at 24-months were positively associated with concurrent child receptive and expressive language scores (Levickis et al., 2014). It is feasible that these associations between responsive behaviours and concurrent language skills might be modified by the JE state in which mother and child are engaged. Specifically, children's sustained attention during SJE may enable them to benefit more from the maternal responsive behaviours than when they are alternating their attention during CJE. However, to date whether JE state modifies the strength of the association between maternal behaviours and child language skills has not been tested.

Purpose of the Current Investigation

The current investigation aimed to answer two questions using a sample of children with language skills spanning the whole language skills distribution.

1. Are supported and coordinated joint engagement at 24-months-old associated with receptive and expressive language scores at 24-, 36- and 48-months-old?
2. Does the level of SJE or CJE modify the association between maternal expansions, imitations and responsive questions and 24-month-old language scores?

We anticipated that SJE but not CJE would be associated with language outcomes at each age and that the positive associations between maternal responsive behaviours and child language skills at 24-months would be modified by JE status.

Method

Participants

The study was nested within a cluster randomized-controlled trial based in a population-level survey, *Let's Learn Language* (NHMRC #384491) and its follow-up, *Language for Learning* (NHMRC #60740) (Wake et al., 2012). Recruitment is described elsewhere (Wake et al., 2011). Participants were recruited at their 12-month-old check-up, offered universally to families in Victoria, Australia. Exclusion criteria were developmental delay, suspected autism spectrum disorder, a major medical condition, or parents with insufficient English to complete questionnaires at grade 6 reading level (typically 11-12 years).

Parents completed a questionnaire at 12-months collecting demographic information. At 18-months, parents completed a screening survey for expressive vocabulary skills, the *Sure Start Expressive Language Measure* (Roy, Kersley, & Law, 2005). Children scoring at or below the 20th percentile were invited into an RCT for a low-intensity parent-toddler language promotion programme (n=301). There were no differences evident in later language outcomes between the intervention and comparison groups (Wake et al., 2011), so the participants are analysed together as a single group in the current study, with all adjusted analyses controlling for intervention group status.

At 24-months, 251 mothers agreed to be video-recorded playing with their child at home. The participants who were and were not video-recorded did not differ in demographic characteristics (Levickis et al., 2014). Data were available for 197 participants in the present

study: 49 did not consent for their data to be used in other studies, four were excluded after receiving an ASD diagnosis at 3- or 4-years, and one was excluded because a caregiver other than the mother took part. There was no evidence that the 197 participants differed from the 251 for whom we had video-recordings, except for maternal age (1.3 years older in this sample).

As shown in Table 1, roughly half of the participants were in the intervention group, half were boys, and half the parents had completed further education. The sample was slightly more socially advantaged than the Australian population on average, evident by a mean Socio-Economic Indexes for Areas (SEIFA) score of disadvantage higher than the Australian mean (M=1000, SD=100). Although the participants had expressive vocabulary scores at or below the 20th percentile at 18-months, their language skills as a group largely normalised, as indicated by face-to-face assessment scores near the normative mean (100) at 24-, 36- and 48-months. Moreover, Table 1 shows that only a minority scored 1.25 standard deviations below the mean at 24-, 36- and 48-months for either receptive or expressive language, a typical cut-off for identifying language disorder in research (Reilly et al., 2010; Tomblin et al., 1997),

[TABLE 1]

Procedure

Parents completed postal questionnaires and participants had face-to-face language assessments in their homes at 24-, 36- and 48-months-old. At 24-months, research assistants, blind to the participants' intervention group status, asked the mothers to play with their children as they normally would for 15-minutes at home using two sets of toys (farmyard and accessories, and doll and accessories). They recorded these interactions onto Sony DVD DS DVD-RW discs using Hitachi DZ-GX5060SW DVD camcorders.

In an earlier study, the recordings were uploaded into Observer XT coding software (Noldus, 2008), and the second author coded maternal responsive behaviours used during the middle ten minutes, using a continuous coding methodology (Levickis et al., 2014). There were no differences in these maternal behaviours between the intervention and control group, suggesting that the intervention did not have an effect on mothers' use of these behaviours in the intervention arm of the RCT. For the present study, the middle five minutes were observed by the first author (the coder) in Windows Media Player and SJE and CJE rated.

Measures

Supported and Coordinated Joint Engagement

SJE and CJE were rated on a seven-point Likert Scale using two items adapted from Adamson et al. (2012), as shown in Table 2. The coder noted the start and end time of each JE episode when mother and child were actively involved with the same object or activity for at least 3 seconds, and whether it was SJE or CJE (based on whether the child looked or spoke to the mother). The coder noted the interaction's quality by considering the matched affect, energy and intensity between mother and child, as detailed in the technical manual (Adamson et al., 2012). Finally, the coder estimated the total time in SJE and CJE to select a point on the Likert rating scale. Each point corresponded to an approximate duration in seconds, based on a five-minute observation. A rating of one indicated there were no JE episodes, four indicated that mother and child were in moderate-quality JE for about a third of the time or briefly in high-quality JE, and seven that they were frequently in rich and varied JE episodes (Adamson et al., 2012). The rating was increased by one point if the quality was appraised to be high.

To test agreement, 10% of the samples were independently rated by a second coder (author #3), blind to the first coder's rating. Unweighted kappas (Cohen, 1960) were 0.5 and

0.7 for SJE and CJE respectively. However, no disagreements exceeded one scale point. Consequently, weighted kappas (Cohen, 1968) that counted one-point disagreements as agreements were 1.0 for SJE and CJE. 10% were also re-rated by the first coder. Intra-rater unweighted kappas were 0.8 and 0.7 for SJE and CJE respectively, and weighted kappas were 1.0 for both.

[TABLE 2 – CODING SCHEME FOR JE]

Language measures

The *Preschool Language Scale 4th edition* (PLS-4) (Zimmerman, Steiner, & Pond, 2002) was administered at 24- and 36-months-old and the *Clinical Evaluation of Language Fundamentals Preschool - Second edition* (CELF-P2) (Semel, Wiig, & Secord, 2006) at 48-months. Subscales from both yield norm-referenced expressive and receptive language standard scores with a mean (M) of 100 and SD of 15. To more readily compare the different measures in analysis, the scores were rescaled to z-scores (M=0, SD=1).

Maternal responsive behaviours

The maternal responsive behaviours that were the focus of this study, described in Table 3, were expansions (repeats and adds to the child's vocalisation), imitations (repeats the child's vocalisation/verbalisation) and responsive questions (asks wh- questions dependent on child's preceding act). These were chosen because they were each associated with better language scores at 24- and 36-months-old. The metric used was rate per minute to control for variation in recording duration.

[TABLE 3 – DEFINITIONS OF MATERNAL RESPONSIVE BEHAVIOURS]

Demographics

Child, maternal, and environmental information identified as potential confounders *a priori* were collected in the baseline questionnaire. These were maternal age, parental

education, birth order (first or later born), birthweight (as a proxy for biological risk), and gender. Neighbourhood disadvantage was measured using the SEIFA score of disadvantage, calculated using census data about household education, employment and occupation, income, and composition (Australian Bureau of Statistics, 2001). Lower scores indicate greater social disadvantage.

Results

As shown in Table 4, on average, the participants were engaged in SJE for at least one third of the time (mean rating = 4.1), compared to CJE in which they were engaged for less than 30-seconds (mean rating = 2.7). This reveals that as a group, the children spent more time attending to the shared object only whilst playing with their mothers than they spent alternating their gaze between the shared object and their mother. There was no evidence of any differences in SJE or CJE ratings between participants in the intervention or control group of the RCT.

[TABLE 4 – SUMMARY STATISTICS FOR JE]

Our first research question asked whether SJE and CJE were associated with receptive and expressive language scores at 24-, 36- and 48-months-old. The correlation matrix in Table 5 shows that higher ratings of SJE, indicating better quality and/or more time spent in SJE, were moderately correlated with better receptive and expressive language scores at 24-, 36- and 48-months. As anticipated, there was no consistent evidence for CJE being correlated with language scores.

[TABLE 5 – CORRELATION MATRIX]

After checking that the assumption of linearity was met by comparing models fitting SJE and CJE as continuous variables to models fitting them as categorical (divided into quartiles), unadjusted linear regression models were run. Next, multivariate models adjusted

for potential confounders (gender, birthweight, birth order, SEIFA score of disadvantage, parental education, maternal age, RCT intervention group). Finally, to see whether the variability in 36- and 48-month language scores explained by SJE or CJE was independent of the child's earlier language skills, 24-month-old language scores (expressive or receptive as appropriate) were added to the multivariate models (as Adamson et al., 2009).

As shown in Table 6, higher SJE ratings were associated with better receptive and expressive language scores at 24- and 36-months after controlling for confounders. Language scores were approximately 0.2 SD higher for every one-point higher SJE rating. Moreover, Table 6 shows that SJE was associated with 36-month language scores after controlling for 24-month-old language scores, although the magnitude of this effect was very small. There was evidence that SJE was associated with receptive language scores at 48-months-old, however evidence of this association diminished once earlier language skills were included.

As can be seen in Table 6, there was no consistent evidence that CJE was associated with language scores at 24-, 36 or 48-months. Although CJE was positively associated with 36-months language scores in the unadjusted models, the effect sizes were small (< 0.2), and the associations did not hold once confounders were added.

[TABLE 6 – REGRESSION FOR QUESTION 1]

Our second question asked whether SJE or CJE modified the association between the maternal responsive behaviours (expansions, imitations, responsive questions) and concurrent child language scores. Since we found no evidence that CJE and language scores were associated, we addressed question two using SJE ratings only.

First, we incorporated an 'SJE by maternal responsive behaviour' interaction term into the models regressing the maternal behaviour on the 24-month-old language scores. These models were compared to models excluding the interaction terms using likelihood ratio tests. As shown in Table 7, only one model supported the interaction term, showing the

association between expansions and 24-month-old receptive language was weaker when SJE ratings were higher (i.e. when more time was spent in SJE). Although a similar pattern can be observed in Table 7 between expansions and expressive language, and between imitations and receptive and expressive language, the interaction terms were not supported. However, because standard tests of interaction can miss subtle effects (Kirkwood and Sterne, 2013), we fitted simple slopes (UCLA Statistical Group) to explore our question further.

[TABLE 7 – INTERACTION EFFECTS]

Figure 1 plots the estimated 24-month-old expressive and receptive language scores by maternal expansions, imitations and responsive questions at each SJE rating (1-7). The positive associations between expansions and imitations and 24-month-old language scores were observed in all but the highest SJE ratings. The associations were weaker at higher SJE ratings, which can also be seen in Table 8. Unlike the other two maternal responsive behaviours, the simple slopes for responsive questions did not support the hypothesis that their association with language scores would differ by SJE rating. There were no SJE levels at which a statistically significant association could be observed (Table 8).

[FIGURE 1 AND TABLE 8]

Discussion

The purpose of this study was to explore: (1) whether SJE and CJE in mother-child interaction at 24-months were associated with language scores at 24-, 36- and 48-months-old, and; (2) whether SJE and CJE modified the positive cross-sectional associations previously found between maternal expansions, imitations and responsive questions and child language scores (Levickis et al., 2014). We found that SJE was positively associated with 24- and 36-month expressive and receptive language scores, but not consistently with 48-month-old scores. There was no evidence that CJE was consistently associated with language scores at

24-, 36- or 48-months. SJE modified how expansions and imitations were associated with cross-sectional language scores, with the associations being evident in all but the highest levels of SJE. In contrast, there was no evidence that SJE modified the association between responsive question and language scores. These findings will be considered in turn, followed by a broader discussion of their contribution to the literature.

Research question 1: The association between JE and language scores

Our findings expand upon previous research that reported that SJE but not CJE at 18-months-old was associated with later expressive vocabulary (Adamson et al. 2004, 2009). We found SJE continues to be important to language development at 24-months-old and is associated with concurrent language skills as well as skills one year later. Our findings also suggest that time spent in SJE may be important to broader domains of language development than word learning, including comprehension and expressive language more generally. This might be because during SJE, children can use their attentional resources to monitor more than verbal labels, including other aspects of the social interaction. Compared to CJE, whilst in SJE children may have more time to process, consolidate, and learn from their experiences (Hirsh-Pasek et al., 2015). Hence, time in SJE may provide the optimal language-learning environment, at least up to age 36-months.

The finding that SJE was no longer associated with expressive or receptive language scores at 48-months-old in the final model may indicate that other child, family or environmental factors become more important to later language development. For example, social disadvantage reportedly becomes more influential in language development between the ages of two and four, perhaps due to an accumulated effect of exposure to poorer language input (Reilly et al., 2010). This 48-month-old finding might be accounted for by a developmental or environmental change common to pre-schoolers. For example, most Australian children start formal kindergarten at 4-years-old, increasing their exposure to

interactions with non-family members, e.g. teachers, peers. These interactions are likely to be important to on-going language learning. They may become more influential than earlier SJE, and therefore account for greater variability in children's language skills at 48-months.

Regarding CJE, our hypothesis that CJE would not be associated with language outcomes was supported. However, it does leave unanswered the question of what role CJE has in language development (Adamson et al. 2009). After all, young children who use frequent eye contact and talk directly to their caregivers, both indicators of CJE, are engaging and rewarding to interact with. And an engaged and motivated adult is likely to continue interacting with that child, providing verbal input and feedback important for language development. Perhaps CJE is associated with other aspects of communication or social development that were not examined in this study, such as pragmatic language or social cognition. This is yet to be investigated to our knowledge.

Research question 2: JE as an effect modifier

The second aim of this paper was to examine whether SJE or CJE modified the associations previously found in this sample between maternal responsive behaviours and language outcomes (Levickis et al., 2014). Whilst CJE was not found to be associated with language outcomes, SJE was observed to modify the association between maternal expansions and imitations and concurrent language outcomes, but not responsive questions.

Maternal expansions and imitations were positively associated with receptive and expressive language scores at all but the highest levels of SJE. At these highest ratings, mother and child are frequently in rich and varied SJE where maternal behaviours may not have the same potential to influence an already optimal language-learning environment. The simple slopes illustrate that even though the association between the expansions and imitations and child language scores is observed at most levels of SJE, the strength of the association is greatest at the lower ratings. This is when the child is spending less time in

SJE. Where SJE is less frequent or of lower quality, expanding upon or imitating a child's utterance, may be especially important.

We found no evidence that SJE modified the association with responsive questions. This might be an artefact of the coding protocol for SJE and CJE. A responsive question necessitates a response from the child. The child's response may lead to a transition in engagement state. For example, if the child answers the question whilst continuing to play with the object and glancing at or responding to their mother, their engagement state will become 'co-ordinated', and the SJE episode will end. If the child does not respond, the mother might terminate the SJE episode depending on her interpretation of the child's non-response. Therefore, the reason why we did not observe an effect modification could be that regardless of the child's level of SJE, maternal responsive questions usually results in SJE ending. An alternative explanation could be that the association between some maternal behaviours and child language is more stable than others, and less likely to be modified by the interactional context in which they are used. For example, the degree to which the maternal behaviour is dependent on the child's preceding behaviour, and hence stage of language development, might be important. Expansions and imitations can only be used in response to a child's preceding verbalisation or vocalisation. In comparison, responsive questions can be asked about anything the child is attending to, regardless of the child's verbalisations or vocalisations. Therefore, use of responsive questions depends less on the child's behaviour, and more on the mother's ability to create opportunities to initiate or maintain the conversation. It might be maternal responsive behaviours that proactively create these conversational opportunities which have the more stable association with language development regardless of the interactional context. Further exploration of the characteristics of maternal behaviours is required to explore these ideas further.

Study strengths and limitations

Study strengths include the large sample size, the prospective, community-based design, the observational measure of SJE and CJE, and repeated face-to-face language assessments. Observational and direct measures can provide a more objective measure than parent report (Hayden, Durbin, Klein, & Olino, 2010). Recording the mother-child playing in the home may also have increased the likelihood of capturing a naturalistic interaction. Finally, the concurrent measures of language skills and JE enabled analytical adjustment for child language ability at the time of the interaction.

Our sample was neither strictly a general population sample, nor a typical late talker sample. It is possible that the parent-child interactions may have been qualitatively different from interactions between parents and children who did not have low expressive vocabulary at 18-months, or those between parents and late talkers. We also cannot rule out that the reason we replicated an earlier study that examined SJE in 18-month-olds (Adamson et al., 2004) was that our sample may have delayed JE skills related to their slower expressive vocabulary acquisition. Caution is therefore required in generalising the findings to a general population sample or a late talker sample.

Socially disadvantaged households were under-represented in our sample, despite efforts to recruit from across socio-economic areas. This is often the case in longitudinal studies (Kiernan & Mensah, 2009), and may mean that the full range of parent-child interactions was not captured, particularly those disproportionately affected by family stress. The change in language measure at 48-months-old, from the PLS-4 to the CELF-P2, means there is the potential for introduced non-equivalence. The change in association between SJE and language scores at 48-months may be due to this change in language measure.

Finally, the quantity of child directed speech heard by the children during the interaction and during each JE episode was not calculated. It was therefore not possible to

quantify the strength of the associations between JE, maternal behaviours and child language scores over and above maternal input quantity and diversity (McGillion, Pine, Herbert & Matthews, 2017).

Future directions

Further investigation is necessary before drawing clinical recommendations from this study. However, possibilities include trialling a version of the SJE scale to use within clinical assessment to identify a child's abilities to participate in interactions that are optimal for language-learning. Investigating how SJE and CJE are associated with existing measures of child attentional skills to determine what additional skills are being captured by the JE ratings over and above attention skills. Understanding which maternal behaviours are modified by SJE and which are not, might be useful for clinicians tailoring individual intervention strategies for young children. Finally, these findings suggest that the supported, or scaffolded, characteristics of joint engagement may be especially important to language learning at 24 months, rather than just the joint engagement alone. By having little responsibility for orchestrating turns or monitoring their mother's interests, the child can take full advantage of the shared attention for language learning. Greater understanding of this scaffolding might inform language promotion approaches to coaching caregivers on how best to support their toddlers during interactions.

Conclusions

This investigation has brought together two separate but related strands of research into child language development; research into the parent-child interactional context, and research into specific types of maternal input. We found that time spent in SJE at 24-months-old made an important contribution to the language-learning environment up to age 36-months, and to the beneficial outcomes associated with some maternal responsive behaviours

used within this environment. Future research should progress this approach with the intention of improving the efficacy of early language intervention strategies.

Table 1: Sample characteristics and summary language scores at 24-, 36- and 48-months-old

Sample characteristics		Total *n*	***n*** (%) or ***M*** (***SD)***
Gender, male		197	103 (52.3)
First-born child		197	73 (37.1)
Birthweight (*g*)		190	3380.3 (620.7)
SEIFA index score of disadvantage [a]		197	1026.5 (53.3)
Maternal age at child age 12-months (years)		197	34.3 (4.5)
In intervention arm of trial		197	100 (50.7)
Parent education: Not complete high school		196	38 (19.4)
Completed high school			65 (33.2)
Completed diploma/tertiary qual/postgrad			93 (47.5)
Receptive language score [b]:	24-months	195	90.6 (14.0)
	36-months	190	98.4 (15.2)
	48-months	193	94.7 (14.0)
Expressive language score:	24-months	195	91.8 (12.0)
	36-months	189	101.1 (14.5)
	48-months	192	97.7 (14.3)
Low receptive score [c]:	24-months	195	63 (32.3)
	36-months	190	24 (12.7)
	48-months	193	33 (17.1)
Low expressive score [c]:	24-months	195	27 (13.9)
	36-months	189	16 (8.5)
	48-months	192	26 (13.5)

Note: [a]SEIFA = Socio-Economic Indices for Area;

[b] *Preschool Language Scale - 4th Edition* at 24- and 36-months-old, and *Clinical Evaluation of Language Fundamentals - Preschool 2nd Edition* at 48-months-old; [c] Low language defined as scoring ≥ 1.25 SD below the standardised mean on expressive or receptive language tests.

JOINT ENGAGEMENT AND LANGUAGE DEVELOPMENT

Table 2: Joint engagement states coding scheme

Joint engagement (JE) (Adamson et al., 2012; Hirsh-Pasek et al., 2015)	Mother and child are actively attending to the same object or event with sustained interest for minimum 3 seconds. Active attending is usually evidenced by manipulation of the object, or being actively focused on the shared activity while one partner manipulates the object. Defined as either supported or coordinated.						
Supported	Child is focusing almost exclusively on the shared object or event (but beyond just listening). Caregiver's participation influences the child's activity/experience with object/event but the child does not acknowledge this involvement. The caregiver is often actively manipulating object or making statements/commands that alter child's actions.						
Coordinated	Child is coordinating attention from object or event to the caregiver. Child is acknowledging the caregiver, often with repeated glances to their face. The caregiver's level of activity directly on the object may be minimal.						
Rating scale	Describes both the quantity and quality of the child's time in joint engagement						
Level	1=	2=	3=	4=	5=	6=	7=
Approximate duration (sec)	0	15	30	90	120	150	>200secs
Rating definition	No episodes of JE			1/3 of time spent in moderate quality, or briefly in highly striking manner			Frequently in rich and varied JE episodes.

Table 3. Definitions of maternal responsive communicative behaviour

Behaviour	Definition	Example
Expansion	Mother repeats one or all of the child's preceding words and adds to the child's preceding verbalization	C: "Ball" M: "It's a red ball"
Imitation	Mother repeats the child's preceding vocalisation or verbalisation exactly or with a reduction in the words.	C: "Ball", M: "Ball"
Responsive Question	Mother asks a "wh" question (e.g. "what", "when", "who"), which is immediate and dependent on the child's preceding act.	Child is playing with horse M: "What's that?"

Table 4: Descriptive statistics for Supported and Coordinated Joint Engagement and maternal use of responsive communicative behaviours

Joint engagement rating (1-7)	*n*	*M (SD)*
Supported joint engagement (SJE)	195	4.1 (1.5)
Coordinated joint engagement (CJE)	195	2.7 (1.3)
Previously coded responsive behaviours (rate per minute) (Levickis et al., 2014)		
Expansion	197	0.6 (0.6)
Imitation	197	0.5 (0.5)
Responsive question	197	0.7 (0.5)

Table 5. Correlation matrix of maternal responsive behaviours, joint engagement, and child language scores at 24-, 36- and 48-months-old.

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Expansion										
Imitation	.58**									
Responsive Question	.25**	.28**								
SJE	.29**	.22*	.26**							
CJE	.25**	.23*	.06	.11						
24m Receptive	.35**	.24**	.15*	.39**	.14					
24m Expressive	.40**	.30**	.18*	.29**	.03	.61**				
36m Receptive	.36**	.17*	.20*	.35**	.16*	.67**	.55**			
36m Expressive	.41**	.22*	.19*	.34**	.16*	.67**	.55**	.80**		
48m Receptive	.31**	.14	.11	.26**	.12	.59**	.41**	.71**	.68**	
48m Expressive	.34**	.13	.14	.20*	.06	.50**	.40**	.67**	.74**	.74**

Note: Items 1-3 are rate per minute, and items 4 and 5 are rated on a 7-point Likert scale; Language skills assessed using *Preschool Language Scale – 4th Edition* at ages 24- and 36-months, and *Clinical Evaluation of Language Fundamentals Preschool 2nd Edition* at 48-months-old.

JOINT ENGAGEMENT AND LANGUAGE DEVELOPMENT

Table 6: Associations between joint engagement state and receptive and expressive language scores at 24, 36 and 48 months-old (n=195)

Age (months)	Language domain	Unadjusted			Adjusted [b]			Adjusted [b] + 24 month language		
Supported JE		ES [c]	95% CI	R^2	ES [c]	95% CI	R^2	ES [c]	95% CI	R^2
24	Receptive	0.3***	0.2, 0.3	0.15	0.2***	0.2, 0.3	0.25			
	Expressive	0.2***	0.1, 0.3	0.08	0.2***	0.1, 0.3	0.20			
36	Receptive	0.2***	0.1, 0.3	0.12	0.2***	0.1, 0.3	0.26	0.1*	-0.0, 0.2	0.52
	Expressive	0.2***	0.1, 0.3	0.11	0.2***	0.1, 0.3	0.25	0.1**	0.0, 0.2	0.4
48	Receptive	0.2***	0.1, 0.3	0.07	0.2**	0.1, 0.2	0.15	0.0	-0.1, 0.1	0.38
	Expressive	0.1**	0.0, 0.2	0.04	0.1	-0.0, 0.2	0.18	0.0	-0.1, 0.1	0.28
Coordinated JE										
24	Receptive	0.1	-0.0, 0.2	0.02	0.0	-0.1, 0.1	0.14			
	Expressive	0.0	-0.1, 0.1	0.00	-0.1	-0.2, 0.0	0.15			
36	Receptive	0.1**	0.0, 0.2	0.02	0.1	-0.1, 0.2	0.18	0.0	-0.1, 0.1	0.51
	Expressive	0.1**	0.0, 0.2	0.02	0.0	-0.1, 0.2	0.18	0.1	-0.0, 0.2	0.38
48	Receptive	0.1	-0.0, 0.2	0.01	0.1	-0.1, 0.2	0.11	0.1	-0.1, 0.1	0.38
	Expressive	0.0	-0.1, 0.2	0.00	-0.0	-0.1, 0.1	0.17	0.0	-0.1, 0.1	0.28

Note: [a] *Preschool Language Scale-4th Edition* at 24 and 36-months-old and *Clinical Evaluation of Language Fundamentals-Preschool 2nd Edition* at 48-months-old, scores rescaled to mean=0, SD=1; [b] Adjusted for child gender, birthweight, birth-order, treatment group, neighbourhood disadvantage score (SEIFA), parent education, maternal age; [c] ES = effect size: interpret as the average standard deviation difference in language score for one point higher rating on SJE or CJE scale.

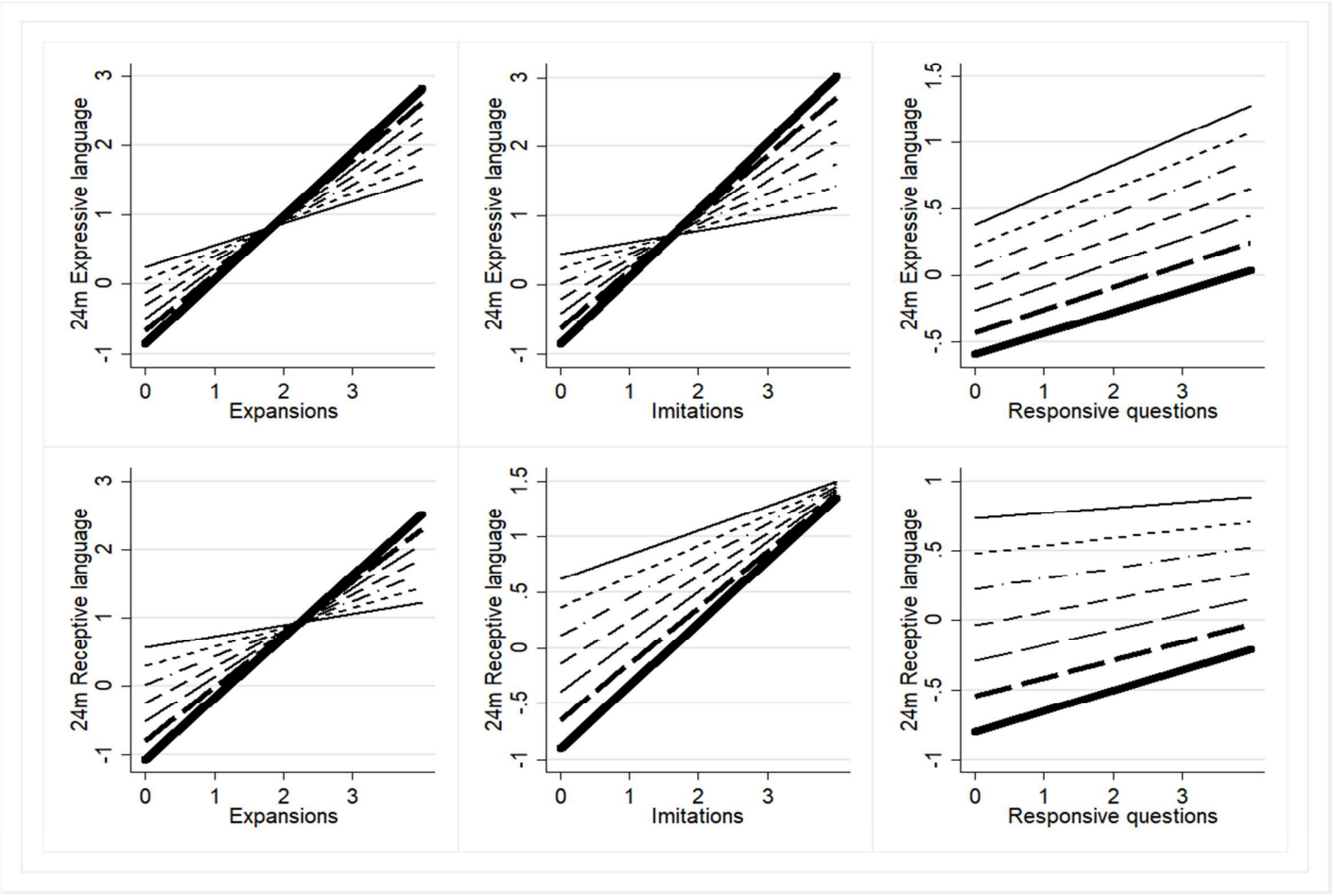
Table 7: Interaction effects of SJE on the association between expressive and receptive language score and maternal responsive communicative behaviours at 24-months-old

Maternal behaviour	Unadjusted		Adjusted [a]	
	Coef.[b]	95% CI	Coef.[b]	95% CI
Receptive language [c]				
Expansions	-0.12*	-0.24, -0.00	-0.10	-0.23, 0.02
Imitations	-0.06	-0.22, 0.10	-0.05	-0.21, 0.11
Responsive Questions	-0.02	-0.17, 0.13	-0.03	-0.20, 0.14
Expressive language [d]				
Expansions	-0.10	-0.22, 0.02	-0.07	-0.19, 0.06
Imitations	-0.13	-0.30, 0.03	-0.14	-0.30, 0.02
Responsive Questions	0.01	-0.14, 0.17	0.04	-0.13, 0.21

Note: CI = confidence interval. [a] Adjusted for child gender, birthweight, birth-order, treatment group, neighbourhood disadvantage score (SEIFA), parental education, and maternal age; [b] interaction coefficient and astrix for *p*-value for likelihood ratio test comparing regression model containing the interaction term with regression model without the interaction term. [c] Language measured using PLS-4 at 24- & 36-months-old, CELF-P2 at 48-months-old (z-scores)

JOINT ENGAGEMENT AND LANGUAGE DEVELOPMENT

Figure 1: Simple slopes modelling effect modification by Supported Joint Engagement on the associations between maternal behaviours and child language scores at 24-months-old. (To be accompanied by Table 8)



* le * levels 1-5

* $p < 0.05$

*] * levels 2-5

Table 8: Simple slope statistics for the association between maternal behaviours and 24-month-old language scores by SJE level (accompanies Figure 1)

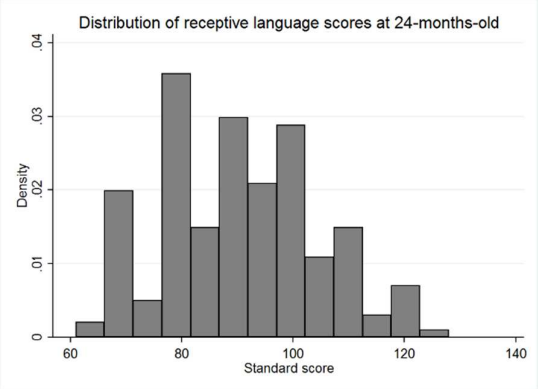
SJE rating	Expressive language		Receptive language	
	ES	95% CI	ES	95% CI
Expansions				
1	0.92***	0.41, 1.43	0.90**	0.40, 1.40
2	0.82***	0.42, 1.22	0.77***	0.38, 1.17
3	0.72***	0.42, 1.02	0.65***	0.36, 0.95
4	0.62***	0.39, 0.85	0.53***	0.30, 0.76
5	0.52***	0.30, 0.73	0.41***	0.20, 0.62
6	0.42**	0.15, 0.68	0.29**	0.02, 0.55
7	0.32	-0.03, 0.67	0.16	-0.19, 0.51
Imitations				
1	0.97**	0.33, 1.61	0.56	-0.07, 1.20
2	0.84**	0.34, 1.33	0.51*	0.02, 1.0
3	0.70***	0.33, 1.07	0.45**	0.08, 0.82
4	0.57***	0.28, 0.86	0.39**	0.11, 0.68
5	0.44**	0.16, 0.72	0.34**	0.06, 0.61
6	0.30	-0.05, 0.66	0.28	-0.08, 0.63
7	0.17	-0.31, 0.65	0.22	-0.25, 0.69
Responsive questions				
1	0.16	-0.44, 0.75	0.15	-0.43, 0.73
2	0.17	-0.29, 0.63	0.13	-0.32, 0.58
3	0.18	-0.17, 0.52	0.11	-0.22, 0.45
4	0.19	-0.08, 0.46	0.09	-0.17, 0.35
5	0.20	-0.07, 0.47	0.08	-0.19, 0.34
6	0.21	-0.13, 0.56	0.06	-0.28, 0.40
7	0.22	-0.24, 0.69	0.04	-0.41, 0.49

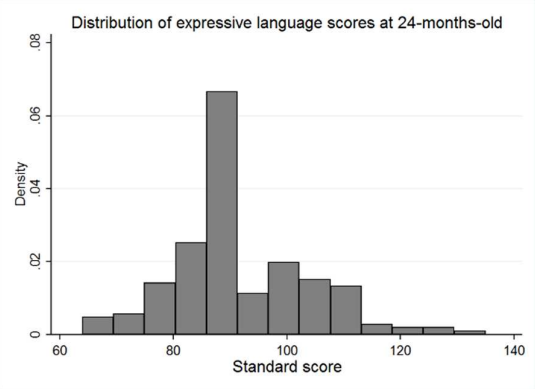
ES=Estimated effect size for the association between maternal behaviour and concurrent language at each level of SJE.

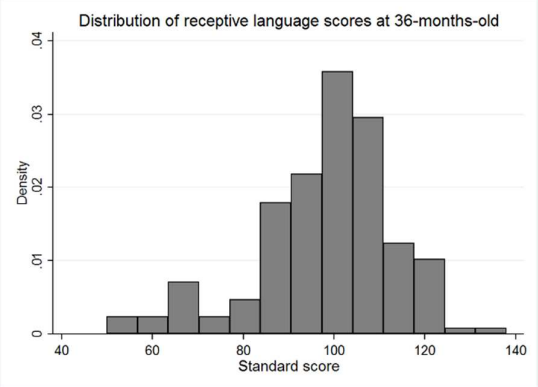
Supplementary figure: Distribution of expressive and receptive language standard scores at 24-, 36-, and 48-months-old

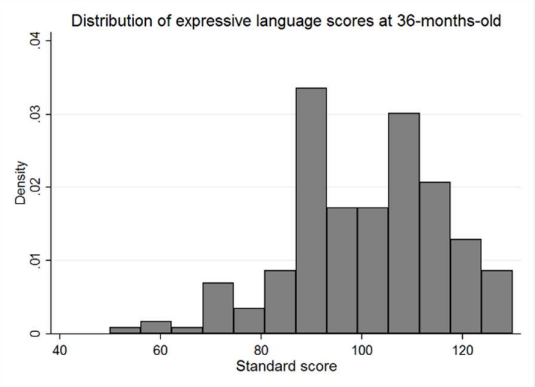
Expressive

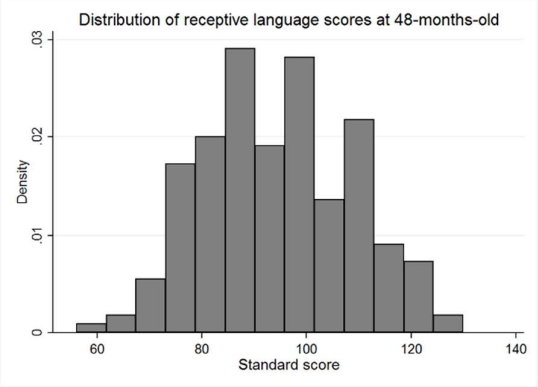
Receptive

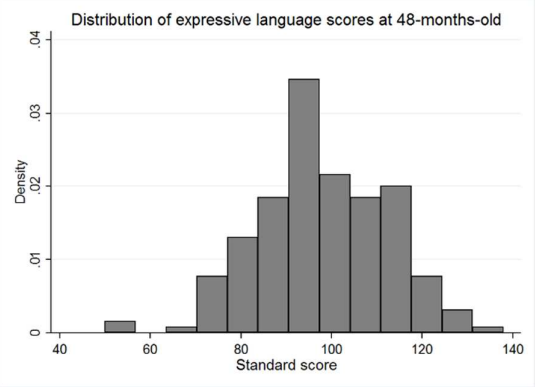












References

Australian Bureau of Statistics (ABS). (2001). *Socio-economic Indexes for Areas* Canberra, Australia: Australian Bureau of Statistics.

Adamson, L. B., & Bakeman, R. (1991). The development of shared attention during infancy. In R. Vasta (Ed.), *Annals of Child Development* (Vol. 8, pp. 1-41). London, UK: Jessica Kingsley Publishers.

Adamson, L. B., Bakeman, R., & Deckner, D. F. (2004). The development of symbol-infused joint engagement. *Child Development, 75*(4), 1171-1187. doi:10.1111/j.1467-8624.2004.00732.x

Adamson, L. B., Bakeman, R., Deckner, D. F., & Nelson, P. B. (2012). Rating Parent-Child Interactions: Joint Engagement, Communication Dynamics, and Shared Topics in Autism, Down Syndrome, and Typical Development. *Journal of Autism and Developmental Disorders, 42*(12), 2622-2635. doi:10.1007/s10803-012-1520-1

Adamson, L. B., Bakeman, R., Deckner, D. F., & Romski, M. (2009). Joint engagement and the emergence of language in children with autism and Down syndrome. *Journal of Autism and Developmental Disorders, 39*(1), 84-96. doi:10.1007/s10803-008-0601-7

Adamson, L. B., McArthur, D., Markov, Y., Dunbar, B., & Bakeman, R. (2001). Autism and joint attention: Young children's responses to maternal bids. *Journal of Applied Developmental Psychology, 22*(4), 439-453.

Akhtar, N. (2005). Is joint attention necessary for early language learning? *The development of social cognition and communication.* (pp. 165-179): Lawrence Erlbaum Associates Publishers, Mahwah, NJ.

Beitchman, J. H., Wilson, B., Johnson, C. J., Atkinson, L., Young, A., Adlaf, E., . . . Douglas, L. (2001). Fourteen-year follow-up of speech/language-impaired and control children: Psychiatric outcome. *Journal Of The American Academy Of Child And Adolescent Psychiatry, 40*(1), 75-82. doi:10.1097/00004583-200101000-00019

Bruner, J. S. (1975). From communication to language – psychological perspective. *Cognition, 3*(3), 255-287. doi:10.1016/0010-0277(74)90012-2

Carpenter, M., Nagell, K., & Tomasello, M. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development, 63*(4), 176. doi:http://dx.doi.org/10.2307/1166214

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychosocial Measurement*, 20, 37-46.

Cohen, J. (1968). Weighted kappa: Nominal scale agreement provision for scaled disagreement or partial credit. *Psychological Bulletin, 70*(4), 213.

Dixon, W. E., & Salley, B. J. (2006). "Shhh! We're tryin' to concentrate": Attention and environmental distracters in novel word learning. *Journal of Genetic Psychology, 167*(4), 393-414.

D'Odorico, L., & Jacob, V. (2006). Prosodic and lexical aspects of maternal linguistic input to late-talking toddlers. *International Journal of Language & Communication Disorders, 41*(3), 293-311. doi:http://dx.doi.org/10.1080/13682820500342976

Dunham, P. J., & Dunham, F. (1995). Optimal social structures and adaptive infant development. In C. Moore & P. J. Dunham (Eds.), *Joint attention: Its origins and role*

in development. (pp. 159-188). Hillsdale, New Jersey:: Lawrence Erlbaum Associates, Publishers.

Farrant, B. M., & Zubrick, S. R. (2012). Early vocabulary development: The importance of joint attention and parent-child book reading. *First Language, 32*(3), 343-364. doi:10.1177/0142723710393795

Hayden, E. P., Durbin, C. E., Klein, D. N., & Olino, T. M. (2010). Maternal personality influences the relationship between maternal reports and laboratory measures of child temperament. *Journal of Personality Assessment, 92*(6), 586-593.

Hirsh-Pasek, K., Adamson, L. B., Bakeman, R., Owen, M. T., Golinkoff, R. M., Pace, A., . . . Suma, K. (2015). The Contribution of Early Communication Quality to Low-Income Children's Language Success. *Psychological Science, 26*(7), 1071-1083. doi:10.1177/0956797615581493

Kannass, K. N., & Oakes, L. M. (2008). The development of attention and its relations to language in infancy and toddlerhood. *Journal of Cognition and Development, 9*(2), 222-246.

Kasari, C., Gulsrud, A., Freeman, S., Paparella, T., & Hellemann, G. (2012). Longitudinal follow-up of children with autism receiving targeted interventions on joint attention and play. *Journal of the American Academy of Child & Adolescent Psychiatry, 51*(5), 487-495.

Kiernan, K. E., & Mensah, F. K. (2009). Poverty, maternal depression, family status and children's cognitive and behavioural development in early childhood: a longitudinal study. *Journal of Social Policy, 38*(4), 569–588.

Kirkwood, B. R., & Sterne, J. A. C. (2013). *Essential medical statistics* (2nd ed.). Malden, Mass: Blackwell Science.

Levickis, P., Reilly, S., Girolametto, L. E., Ukoumunne, O. C., & Wake, M. (2014). Maternal behaviors promoting language acquisition in slow-to-talk toddlers: Prospective community-based study. *Journal of Developmental and Behavioral Pediatrics, 35*(4), 274-281. doi:10.1097/dbp.0000000000000056

McGillion, M., Pine, J. M., Herbert, J. S., & Matthews, D. (2017). A randomised controlled trial to test the effect of promoting caregiver contingent talk on language development in infants from diverse socioeconomic status backgrounds. *Journal of Child Psychology and Psychiatry*, 58(10), 1122-1131. doi:10.1111/jcpp.12725

Moore, C., & Dunham, P. J. (1995). *Joint attention: Its origins and role in development*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Mundy, P., Block, J., Delgado, C., Pomares, Y., Van Hecke, A. V., & Parlade, M. V. (2007). Individual differences and the development of joint attention in infancy. *Child Development, 78*(3), 938-954. doi:10.1111/j.1467-8624.2007.01042.x

Noldus. (2008). The Observer XT (Version 8.0)

Paul, R., & Shiffer, M. E. (1991). Communicative initiations in normal and late-talking toddlers. *Applied Psycholinguistics, 12*(4), 419-431. doi:http://dx.doi.org/10.1017/S0142716400005853

Reilly, S., Wake, M., Ukoumunne, O. C., Bavin, E., Prior, M., Cini, E., . . . Bretherton, L. (2010). Predicting language outcomes at 4 years of age: findings from Early Language in Victoria Study. *Pediatrics, 126*(6), e1530-e1537. doi:10.1542/peds.2010-0254

Rescorla, L., Bascome, A., Lampard, J., & Feeny, N. (2001). Conversational patterns in late-talkers at age 3. *Applied Psycholinguistics, 22*(2), 235-251. doi:http://dx.doi.org/10.1017/S0142716401002053

Roy, P., Kersley, H., & Law, J. (2005). *The Sure Start language measure standardisation study*. Retrieved from http://tna.europarchive.org/20070101101348/

http://www.dfes.gov.uk/research/programmeofresearch/projectinformation.cfm?projectid=14628&resultspage=1

Semel, E., Wiig, E. H., & Secord, W. A. (2006). *The Clinical Evaluation of Language Fundamentals-Preschool, Second Edition (CELF-P2): Australian Standardised Edition*. NSW, Australia: Harcourt Assessment Inc.

Tomasello, M., & Farrar, M. J. (1986). Joint attention and early language. *Child Development, 57*(6), 1454-1463. doi:10.1111/j.1467-8624.1986.tb00470.x

Tomblin, J. B., Records, N. L., Buckwalter, P., Zhang, X. Y., Smith, E., & O'Brien, M. (1997). Prevalence of specific language impairment in kindergarten children. *Journal of Speech, Language and Hearing Research, 40*(6), 1245-1260.

Trueswell, J. C., Lin, Y., Armstrong, B., Cartmill, E. A., Goldin-Meadow, S., & Gleitman, L. R. (2016). Perceiving referential intent: Dynamics of reference in natural parent-child interactions. *Cognition, 148*, 117-135. doi:10.1016/j.cognition.2015.11.002

UCLA Statistical Consulting Group. How can I explain a continuous by continuous interaction? *Stata FAQ*.

Wake, M., Levickis, P., Tobin, S., Zens, N., Law, J., Gold, L., . . . Reilly, S. (2012). Improving outcomes of pre-school language delay in the community: Protocol for the Language for Learning randomised controlled trial. *Bmc Pediatrics, 12*, 1-11. doi:10.1186/1471-2431-12-96

Wake, M., Tobin, S., Girolametto, L. E., Ukoumunne, O. C., Gold, L., Levickis, P., . . . Reilly, S. (2011). Outcomes of population-based language promotion for slow-to-talk toddlers at ages two and three years: Let's Learn Language cluster randomised controlled trial. *BMJ, 343*, d4741-d4741. doi:10.1136/bmj.d4741

Vuksanovic, J., & Bjekic, J. (2013). Developmental relationship between language and joint attention in late talkers. *Research in Developmental Disabilities, 34*(8), 2360-2368. doi:10.1016/j.ridd.2013.04.017

Yu, C., & Ballard, D. H. (2007). A unified model of early word learning: Integrating statistical and social cues. *Neurocomputing, 70*(13), 2149-2165.

Zimmerman, I. L., Steiner, V. G., & Pond, R. E. (2002). *The Preschool Language Scale, 4th Edition*. San Antonio, TX: The Psychological Corporation.

Supplementary figure: Distribution of expressive and receptive language standard scores at 24-, 36-, and 48-months-old

Expressive

Receptive