Parents modify gesture according to task demands and child language needs.

Abstract

Parent-child interaction plays a crucial role in early language acquisition. In young typically developing children, direct and indirect relationships between parent gesture, child gesture and child language have been observed. Far less is known about these relationships in atypical language development. The present study investigated parent gesture frequency in relation to child gesture frequency and language ability. Parent-child dyads were observed for children aged 6-8 years with developmental language disorder (DLD: n=21) relative to parents of typically developing peers (TD: n=18) and children with low language (LL) and educational concerns (n=21). Parents of children with DLD gestured at significantly higher rates than parents of TD children, but only during a complex interactive problem solving task. Across the entire sample, parent gesture rate was positively correlated with child gesture rate, but negatively correlated with child vocabulary. Parent gesture thus may serve as a strategy to maximise communication success for children with language difficulties and is most evident when communication demands are high.

Introduction

Parent-child interaction plays a crucial role in early child language acquisition; it is through these early interactions that children learn the semantic and linguistic structures and social cues required for language development (Snyder-McLean & McLean, 1978). An important aspect of parent-child interaction is that parents are dynamic, constantly changing and adapting their communication to meet the demands of the situation and the needs of their child (Tamis-LeMonda et al., 2008). Child directed speech is a well-documented phenomenon that supports parent-child communication, but it is also common for parents to use co–speech gestures that are child directed to engage the child and enhance communication (Iverson, Capirci, Longobardi, & Caselli, 1999). For example, parents are more likely to produce larger, less complex gestures when communicating with their infant, in comparison to communication with an adult (Brand, Baldwin, & Ashburn, 2002; Iverson et al., 1999; Özçaliskan & Goldin-Meadow, 2005). Such observations prompt questions about whether these child directed gestures are a critical component of early language acquisition and/or language learning throughout childhood. A second question concerns how parent gesture affects language learning when child language follows an atypical developmental course, for example, in children with developmental language disorder (DLD).

DLD is a disorder that affects 7.58% of children at school entry (Norbury et al., 2016) and is generally identified when a child exhibits persistent difficulties in acquiring and using language. These difficulties may include deficits in the comprehension or production of vocabulary, grammar and/or discourse (American Psychological Association, 2013) and occur in the absence of other developmental concerns, sensory impairments or intellectual disability (though DSM5 criteria does not

stipulate a discrepancy between verbal and non-verbal abilities is required for diagnosis). Exploring the impact of parent gesture on child language development within this disorder is of interest as children with DLD are thought to have a typical drive to communicate, but have deficient oral language skills relative to peers (Bishop, 2000). In addition, this area of research has potentially important implications for parent-based interventions aimed at using non-verbal communication to support language and communication. However, the majority of research to-date has focused on the relationship between parent gesture, child gesture and child language abilities in young typically developing children. These studies (reviewed below) lead to the prediction that parent gesture may be even more important for driving language development in atypical populations. However, very little is known about these relationships in populations of children with language and communication deficits, which is the focus of our study.

Parent gesture supports typical language and communication development

Across cultures, parents who gesture frequently also have children who gesture frequently (Goodwyn & Acredolo, 1993; Iverson et al., 1999; Liszkowski, Brown, Callaghan, Takada, & de Vos, 2012; Rowe & Goldin-Meadow, 2009a; Rowe, Özçalışkan, & Goldin-Meadow, 2008). This positive relationship indicates that children observe parents' use of gesture and subsequently adopt this strategy to enhance their own communication. Parent gesture is also positively associated with young typically developing children's language ability (Iverson et al., 1999; Pan, Rowe, Singer, & Snow, 2005). For example, parental use of pointing gestures is positively related to children's vocabulary at 14 months (Pan et al., 2005) and 16 months (Iverson et al., 1999). However, Rowe, Özçalışkan, and Goldin-Meadow (2008) reported an indirect

relationship between parent gesture and child language, in which parent gesture vocabulary predicted child gesture vocabulary, which in turn predicted child oral vocabulary. Methodological differences between studies challenges interpretation of causal relationships; both Iverson et al. (1999) and Pan et al. (2005) report a relationship with deictic (finger pointing) gestures, whereas Rowe et al. (2008) combined all gesture types. Thus, the mechanisms by which different gesture types facilitate language learning may vary. Deictic gestures may facilitate language growth by establishing joint attention of referents (McGregor, 2008) and accompanying parent labelling behaviours (Gogate, Bahrick, & Watson, 2000), helping those words to enter a child's verbal lexicon. Alternatively, representational gestures may reinforce the spoken message and provide more complex information about a referent's size, shape or motion (McNeill, 1992), which may lead to a greater depth of semantic understanding of the referent once the word has entered a child's verbal lexicon (Singleton, 2012).

Intervention studies further highlight the link between parent-child gestures and language development. Goodwyn, Acredolo, and Brown (2000) trained parents to either increase their verbal labelling, or increase their verbal and symbolic gestural input. In addition their study included a control group who received no intervention. Goodwyn et al. (2000) found that those children whose parents had been encouraged to use gesture showed the largest gesture repertoire and achieved significantly higher scores on measures of receptive and expressive language. However, the gesture advantage did not persist when children were re-assessed at 30 and 36 months, suggesting that gesture may only be influential in the earliest stages of language acquisition.

Child gesture use is positively associated with child language

Positive associations between early child gesture use and both later child vocabulary and sentence complexity have been consistently reported (Acredolo & Goodwyn, 1988; Rowe & Goldin-Meadow, 2009b; Rowe et al., 2008) at least in early childhood. Once again, the mechanism by which child gesture facilitates language learning is not well understood. One possibility is that early child gesture may not play a <u>causal</u> role in language learning per se, but may be a marker for language learning potential (Rowe & Goldin-Meadow, 2009b). For example, those children who find producing gesture-speech combinations easy may also subsequently learn complex sentences more readily. Another possibility is that gesture may play a more active role in language learning, as gesture provides children with the opportunity to practice more complex sentence structures before they can articulate such structures (Ozçalişkan & Goldin-Meadow, 2005). In addition, gesture may elicit verbal responses from parents, which further facilitates language learning (Goldin-Meadow, Goodrich, Sauer, & Iverson, 2007). For example, imagine that a child points to a bird and says "fly", and the parent responds "yes <u>birds</u> fly!" The parent is providing the child with verbal translation of the gesture–word combination that both increases the likelihood of the word "bird" entering the child's verbal lexicon (Goldin-Meadow et al., 2007), and extends the child's length of utterance. Such findings signal reciprocal relationships whereby child language and gesture behaviour may influence parent language and gesture behaviour as much as parent behaviours drive child language and gesture development.

Parent gesture use in atypical populations

The positive associations among parent gesture, child gesture and child language suggest that gesture use in parents of children with language and communication disorders should be beneficial. However, surprisingly little is known about how parents

of children with atypical language and cognitive development use gesture, and whether parent gesture has the same relationships with child language in these populations. In these populations, gesture is often regarded as a compensatory tool, rather than a driver of language acquisition. For example, parents of children with Down syndrome use simpler verbal language but gesture more frequently with their child during problem solving tasks, relative to parents of TD children (Iverson, Longobardi, Spampinato, & Caselli, 2006). In addition, negative relationships between parents' use of pointing gestures and child language have been reported for children with autism spectrum disorders, aged 7-18 years old (Medeiros & Winsler, 2014), in contrast to the relationship between parent gesture and child language reported for TD children (Iverson et al., 1999; Pan et al., 2005). While these differences may reflect compensation for child language deficits, it is also possible that methodological differences affect parent gesture behaviour. For example, Iverson et al. (1999) and Pan et al. (2005) measured gesture use during observations of free play in TD infants, whereas Medeiros and Winsler (2014) observed gesture during observations of parents and school-aged children completing a problem solving task. A more complex problem solving task may elicit higher gesture rates when the goal is to aid child understanding and successful task completion. Group differences may therefore be more evident in contexts that are more challenging for children with language deficits.

In relation to children with DLD, the paucity of available research indicates that parents may modify their gesture in relation to their child's language ability. For example, Lasky and Klopp (1982) observed parent behaviour during shared book reading, a cognitive problem solving task, and free play. They found that parents who used more non-verbal behaviours (facial expression, body posture, action,

demonstration, gesture and imitation) had children with more severe language difficulties. Lavelli, Barachetti, and Florit (2015) similarly reported that during shared book reading, parents of children with DLD (aged 3;5-5;6 years) behaved more similarly to parents of younger language-matched TD children, with both groups producing more combined gesture-speech utterances than parents of the age matched TD group. They also reported a trend for parents of the DLD children and language-matched TD children to gesture at a higher rate (defined by number of gestures per minute) than the age-matched TD group. Whilst their findings do suggest that parents modify their communication in line with the language abilities of their child, this study only explored gesture use during shared book reading and as a result, the majority of gestures produced were pointing gestures. It is therefore difficult to know whether these findings would generalise to different parent-child interaction scenarios or whether parents' use of representational gestures also support language. Furthermore, it is unclear whether parents of children with DLD use gesture in different ways, not only dependent on the language ability of their child, but also according to task demands.

Grimminger, Rohlfing, and Stenneken (2010) measured parent gesture during an interactive comprehension task with late-talking toddlers aged 22-24 months. Parents instructed their child to arrange objects that had either a canonical ("put the girl on the chair") or a more complex non-canonical ("put the girl under the chair") spatial relationship (Grimminger et al., 2010). Overall, mothers of late-talking children gestured more frequently and were more likely to hold a gesture throughout an utterance than parents of TD children. In addition, parents of both TD and late-talking children produced more gestures during the more demanding non-canonical setting, suggesting

that whilst all parents increase gestures when task demands are high, this is more pronounced when a child's language ability is low.

In summary, parents may adopt different gesture-communication strategies depending on the language needs of their child and the complexity of the interactive task. For children with DLD, gesture may be used primarily as a compensatory strategy to support communication, and may therefore be <u>negatively</u> correlated with the child's language abilities, rather than positively associated as seen in typical language development. However, the literature regarding parent gesture in relation to children with DLD is sparse and those studies which have explored this relationship are limited by the types of gestures their tasks elicit, the extent to which other factors such as task demands are considered and severity of language difficulties. For example, the 'late talking' toddlers in Grimminger et al., 2010 may have been displaying transient early language delay and so the severity of their language difficulties may have differed from children with more persistent language disorder.

The current study investigated parent gesture in three groups of children representing the full range of oral language abilities: those with typical language development (TD), an intermediate group of children with low language and educational concerns (LL) and those with persistent developmental language disorder (DLD), across two different gesture production tasks. This study has a number of advantages over previous research; first, to our knowledge, no studies of children with DLD have explored how parent gesture relates to child gesture, and how the child's gesture is in turn associated with language competencies. In DLD, parent gesture may signal an additional means to enhance communication when verbal skills are not developing as expected, and/or may prompt parents to reformulate the child's gesture

using verbal language. Second, we have measured gesture across two spontaneous gesture tasks, a narrative monologue and an interactive problem solving task, which enabled us to explore parent gesture across tasks with different cognitive and linguistic demands. Finally, a major strength of the current research is the inclusion of children with a wide range of language abilities, which enabled the gesture-language relationship to be examined across the whole spectrum of language ability.

The study had three main aims; first we aimed to establish whether parents modify gesture use depending on their child's language ability and/or task demands. Here we predicted that parents of children with DLD would generally gesture more frequently, but that an increased gesture rate might be especially evident in an interactive problem solving task relative to a narrative monologue task. Our second aim was to establish whether there were positive relationships between parent gesture and (a) child gesture, and (b) child language in children with varying levels of language competence. We anticipated that parents who gestured more frequently would have children who also gestured more frequently in all three groups. However, in contrast to TD studies, we predicted that parents who gestured more frequently might in fact have children with more severe DLD, reflecting the need to use gesture to support communication. Finally we asked whether child gestures were associated with the amount of verbal language that parents provided. If so, this would provide some support for the tentative claim that child gesture facilitates child language development by eliciting richer linguistic input from parents.

Method

Participants

Participants comprised 63 children aged 6-8 years, and their parent. Children were recruited as part of the Surrey Communication and Language in Education Study (SCALES, a population study of DLD at school entry; Norbury et al. 2016). Reception class teachers completed the Children's Communication Checklist-S (CCC-S, a short-form of the CCC-2, Bishop, 2003) for 7,267 children aged 4-5 years old in state-maintained schools in Surrey, a county in South East England (Stage 1). From this teacher-rated assessment, the bottom 14% (stratified by season of birth and gender) of children were classified as high-risk (HR) for developmental language disorder, whilst children scoring above this threshold were classified as low-risk (LR) of DLD. Selection for Stage 2 used cut-off scores on the CCC-S for each of the three age-groups (autumn, spring, and summer born) to identify sex-specific strata of boys (13. 9%) and girls (14. 8%) with teacher ratings of poorer language relative to children of similar age and sex. In total, 636 monolingual children were invited to participate, with a higher sampling fraction for high-risk children (40. 5% of high-risk boys, 37.5% high-risk girls) versus low-risk children (4.3% for boys, 4. 2% for girls). In Stage 2, 529 children (83% of invited cohort) participated in an in-depth assessment of language, non-verbal cognition and motor skills (ages 5-6 years; 329 HR and 200 LR children, see Norbury et al 2016, for details).

For the current gesture study, we initially aimed to visit 10% of the total in-depth cohort, over-sampling high-risk children at a ratio of 2:1. One hundred and thirty families were invited to take part in the study; 50 families did not consent to the home visit and/or video recording of testing sessions. A further eleven families initially

consented, however suitable arrangements could not be made for the home visit. Sixty-three monolingual parent-child dyads (61 mother-child) consented and were observed for this study when children were 6-8 years old. Three families of children reported diagnosis of ASD and were excluded from further analysis. There were no statistically significant differences between those families who opted in and those that opted out, on measures of socio-economic status, t(111) = -.08, *p*=.937, reported concerns about speech and language development, χ^2=1.06, *p*=. 304, or language risk status, χ^2=1.58, *p*=.209 (Opt-in: 65% high risk; Opt-out: 76% high risk).

Group Classification

Prior to the home visits for the current study, children completed an in-depth test of language and cognitive function at school. A total language composite score was derived from tests of expressive and receptive vocabulary (Brownell, 2000); receptive and expressive grammar (Marinis, Armon-Lotem, Piper, & Roy, 2011; Bishop, 2003); narrative retelling and comprehension (Adams, Cooke, Hesketh, & Reeves, 2001). The core language battery consisted of tests that did not have current UK standardisations, either because they were standardised in North America, or were recently developed. Furthermore, co-standardising measures allows for direct comparison across measures. We therefore adjusted raw scores for child age using the full weighted SCALES sample (see Norbury et al. 2016 for details of this procedure). Children were assigned to one of three groups on the basis of their CCC-S and total language composite scores; there was no significant group differences in gender, $X^2 = 6.81$, *p* =.08. The DLD group (n = 21, 15 males) had total language composite z-scores of -1SD or greater below the population mean. TD children (n = 18, 8 males) scored above the -1SD cut-off on both the CCC-S and the total language composite. Twenty-one children scored -1SD below

the population mean CCC-S, indicating teacher ratings of significant communication deficits in their first year of school (ages 4-5). However, these children scored above the 1SD cut-off on the total language composite in Stage 2 of SCALES (ages 5-6 years). As a group, they obtained intermediate total language composite scores that were significantly poorer than TD peers, and significantly higher than children with DLD (see Table 1). In addition, eight of these children were receiving special education support at school and six had been referred to speech-language therapy services. Due to their history of language and communication concerns and ongoing special educational needs, they were not combined with the TD group, but instead formed an intermediate group of children with low language and educational concerns (LL: n=21, 9 male). Including this intermediate group ensured that we could explore gesture use in relation to language across the whole spectrum of language abilities.

A cut-off of 1SD below the mean on a total language composite score was chosen as it has been suggested that even children -1SD below the mean experience functional language deficits (Reilly et al., 2014). Indeed, 90.5% of children with DLD in the current study were rated by teachers as not achieving a good level of development on the Early Years Foundation Stage Profile (EYFSP: an assessment of academic attainment used in the UK) at the end of their first year at school.

The study protocol was approved by the Royal Holloway Research Ethics Committee. All families had consented to be contacted for future studies; these families were contacted by post and parents provided informed, written consent for participation in the current study. Consent included a home visit by the first author and video recording of all the gesture tasks. Each home visit lasted approximately 90 minutes.

Table 1.

Mean (SD) on background measures of age, neighbourhood deprivation, non-verbal reasoning, total language composite scores and expressive/receptive vocabulary composite for children in each language group.

Measure	TD (n=18)	LL (n=21)	DLD (n=21)	F	p	η^2
Age (months)	87.50	89.00	89.19	.56	.575	.02
	(5.53)	(5.11)	(5.54)			
IDACI rank scores	24721.28 [a]	23278.33 [a,b]	19357.91 [b]	3.36	.042	.11
	(4966.74)	(6346.25)	(8302.65)			
Non-verbal Reasoning	29.00 [a]	26.48 [a,b]	24.19 [b]	6.88	.002	.51
	(4.86)	(3.57)	(3.68)			
Language composite	.61 [a]	-.40 [b]	-1. 67 [c]	61.49	<. 001	.68
	(.81)	(.45)	(.62)			
Vocabulary Composite	174.11 [a]	154.05 [b]	129.71 [c]	40.76	<. 001	.59
	(20.07)	(10.64)	(14.81)			

Note. TD: typically developing, LL: low language, DLD: developmental language disorder. All means are raw scores other than the language composite which is reported as a z-score. IDACI: Deprivation Affecting Children Index rank scores. Different superscripts within the same row indicate differences between group means that are significant at p < .05

Procedure

Background measures were collected in each child's school, when there were visited as part of the SCALES study. Following this children and parents were visited at home by the first author. During the home visit, children and parents completed a number of structured and semi-structured gesture tasks. Child gesture data are reported elsewhere (Wray et al. 2017).

Background Measures

Background measures for all children were collected through the SCALES project which included vocabulary, non-verbal IQ and a measure of social economic status (see Norbury et al 2016 for full assessment battery). As previous research has focused on the link between vocabulary and gesture use (Rowe & Goldin-Meadow, 2009a; Rowe et al., 2008), the current paper used a composite of the Receptive One word Picture Vocabulary Test (ROWPVT; Brownell, 2000b) and Expressive One Word Picture Vocabulary Test (EOWPVT; Brownell, 2000a), to index vocabulary. In addition, non-verbal IQ was assessed using the WISC Block Design (Wechsler, 2003) and social economic status was estimated using the Income Deprivation Affecting Children Index rank scores (IDACI). This measure assessed SES using children's home post codes. Scores in England range from 1 (most deprived) to 32,844 (most affluent), with a mean of 16,352 (data from 2010).

Narrative Recall

During the home visit parents watched two wordless cartoons (Die Sendung mit derMaus: www. wdrmaus.de/lachgeschichten/spots.php5) of 30-60 seconds duration that depicted a

mouse and an elephant in different scenarios. Cartoons were presented one at a time to parents on a laptop, and they were asked to re-tell the story to their child, who had not seen the video (McNeill, 1992). Videos were shown once and no specific instructions regarding story re-telling or using gesture were given. Children were asked to listen to their parent tell the story and were given no further instructions. The order of presentation was counterbalanced across participants.
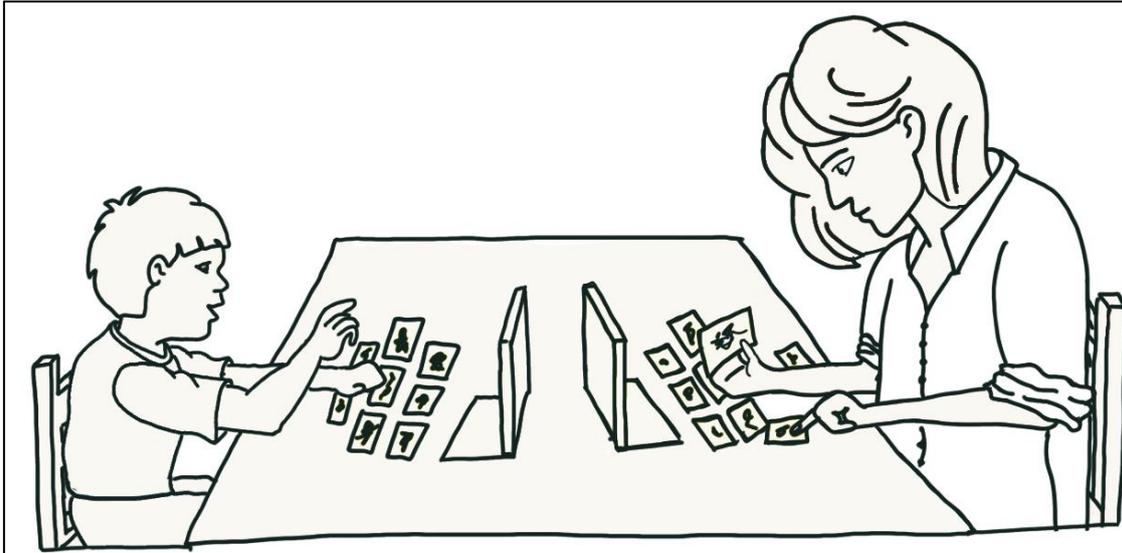

Figure1. Experimental set-up for the Referential Communication task.

Referential Communication Task

In this task, parent and child sat opposite each other and both had a board in front of them which the other person could not see, though they could see each other (see Figure 1). Children and parents performed both describer and listener roles across four trials, which were counterbalanced across participants. The child always started in the describing role and this alternated thereafter. The describer was given a board with eight pictures of one animal (cats, dogs, mice or rabbits) displayed in a specific order on a 4x2 grid (Figure 2). All drawings were in black and white and were designed to be visually similar. The listener was given a blank board and 12 cards, which included the eight target cards and four distractor cards. The describer was instructed to describe

each of their cards and the order that they appeared so that the listener could locate the correct card and place it in the correct position. Parents and children were free to communicate naturally throughout the task, they were told that they could ask each other as many questions as they wanted to and were not given a time limit to complete the task.
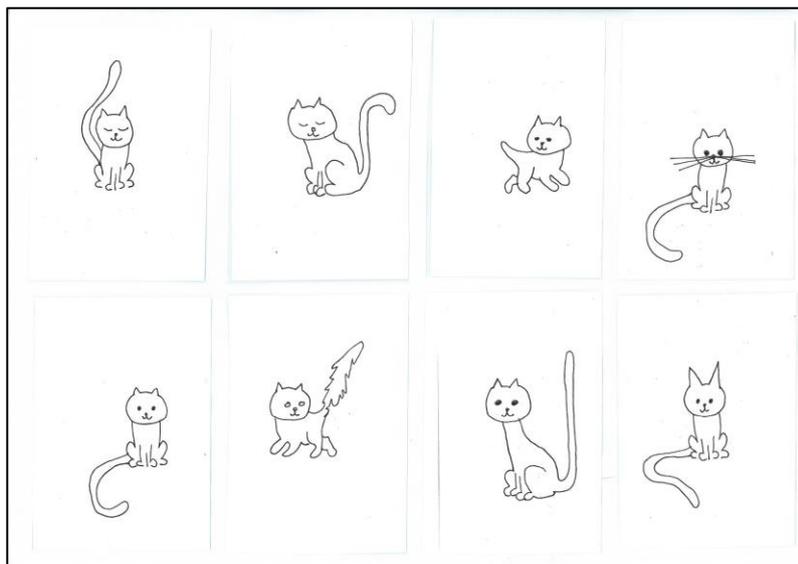

Figure 2. Example experimental stimuli for the Referential Communication task.

Verbal transcription and gesture coding of narrative and referential communication tasks.

Verbal dialogue in both tasks was transcribed using Systematic Analysis of Language Transcripts software (SALT; Miller & Iglesias, 2012). Total number of words, number of different words and mean length of utterance were calculated for each task. Gestures were coded from the videos by the first author and a trained research assistant using Observer XT software (Grieco, Loijens, Zimmermann, & Spink, 2013). A gesture was defined as a movement of any body part that expressed and idea or meaning. Although predominantly hand movements were observed, gestures could also include

head or other body movements too (e.g. moving legs to indicate running). When identifying gestures to code, the entire gesture phrase was considered (Kendon, 2000). The number of different gesture types produced by parents during the narrative and referential tasks, and for children during the referential task were coded. Gesture types included: Deictic gestures, which are pointing gestures used to draw attention to a particular object, person or location in the environment; Representational gestures, which show a close relationship to the object, action, idea or concept that they refer to (e. g. making a circular shape with hand to represent a ball); Conventional gestures, which are culturally specific and convey meaning without the need for speech (e. g. nodding to symbolise yes); and Beat gestures, which are rhythmic movements that emphasise aspects of speech (McNeill, 1992). The total number of gestures (combining all gesture types) formed a raw gesture score. The number of gestures per 100 words was calculated (number of gestures/ number of words x 100) to provide a gesture rate that accounted for the number of words that the parents used during each task.

Gesture function was also coded as either extending or redundant. Extending gestures included gestures that were produced with speech but which added extra information (e. g. "the cat had a tail like that", whilst simultaneously producing a *curly tail* gesture) and also gestures produced in isolation, in the absence of the verbal equivalent. Redundant gestures included gestures that reinforced the spoken message; although these gestures may highlight important aspects of an utterance, they do not add extra information to the utterance (e. g. "the cat had a curly tail", whilst simultaneously producing a *curly tail* gesture). Gesture function was coded for all gesture types produced. However, because of the nature of beat gestures it is difficult to categorise

them as either 'redundant' or 'extending', as such beat gestures were excluded from

analyses of gesture function.

Reliability

For both tasks, 10% of participants, parent gesture was double coded by a second rater,

blind to the child's diagnostic group and study hypotheses. The inter-reliability for the

referential task was 72% agreement (kappa = .69), while inter-reliability for the

narrative task was 83% agreement, (kappa = .74), which indicates acceptable reliability

for both tasks (Landis & Koch, 1977). Disagreements were resolved through discussion.

Results

Data analysis plan

Analyses focused on differences in parent gesture rate, gesture function and parent

language in relation to child gesture rate and child language ability, a 2 (task: narrative,

referential) x 3 (group) repeated measures ANOVA was conducted to explore group

differences in gesture frequency and gesture function across tasks. Cohen's d effect

sizes are reported and interpreted as an effect size of .2 is a small effect, .5 a medium

effect and .8 a large effect (Cohen, 1988). Group and task comparisons of the referential

communication task focused on trials in which the parent was in the describing role, as

this enabled us to explore how parents used gesture during child directed speech. Later

correlation analysis looked at the relationship between parent gesture, child language

and child gesture across the whole task (taking into account when parent and children

are in both roles) to examine the relationship between language and gesture across the

entire interaction. As previous research has focused on the link between vocabulary and

gesture use (Rowe & Goldin-Meadow, 2009a; Rowe et al., 2008), the current paper used a composite expressive and receptive vocabulary.

Parent language

Table 2 and 3 demonstrate that there were no significant groups differences in the number of words produced by parents during narrative recall, F(2,57) = 2.62, *p* = .082, η_p^2 =.08, or referential communication, F(2,57) =. 38, p = .686, η_p^2 =.01, nor was there a significant difference in the MLU for either task (Narrative: F(2,57) = 2.49, *p* =.092, η_p^2 =.08; Referential: F(2,57) =.16, *p* = .849, η_p^2 =.01) (See Table 2 and 3 for means). Thus the amount and complexity of the verbal information that parents provided was broadly similar across groups.

Table 2.

Means (SD) of verbal language and gesture rate by parents and child gesture rate during the narrative task.

Measure	TD (n=18)	LL (n=21)	DLD (n=21)	F	*p*	η_p^2
Parent Total Words	290.22 (106.13)	233.29 (95.88)	221.81 (94.66)	2.62	.082	.08
Parent MLU	7.91 (.82)	7.35 (.87)	7.47 (.72)	2.49	.092	.08
Parent Gesture Rate	8.67 (2.95)	8.31 (4.20)	7.39 (4.19)	.582	.562	.02

Note. TD: typically developing, LL: low language, DLD: developmental language disorder. All data is raw data other than gesture rate which is number of gestures per 100 words

Table 3.

Means (SD) of verbal language and gesture rate for parent and children for the referential communication task.

Measure	TD (n=18)	LL (n=21)	DLD (n=21)	F	p	η_p^2
Parent Total Words	1386.39 (512.77)	1289.90 (461.58)	1251.00 (426.94)	.38	.686	.01
Parent MLU	5.02 (.91)	4.93 (.75)	5.07 (.66)	.16	.849	.01
Parent Gesture Rate (whole task)	1.16 [a] (.82)	1.66 [ab] (.68)	2.02 [b] (1.40)	3.21	.048	.10
Parent Describer Gesture Rate	2.65 [a] (1.75)	4.10 [ab] (1.86)	4.73 [b] (2.33)	5.17	.009	.16
Child Gesture Rate (whole task)	2.64 [a] (.80)	3.88 [b] (1.24)	3.82 [a,b] (2.31)	3.51	.037	.11
Child Extending Gestures (raw score)	22.82 (17.19)	18.71 (8.74)	25.19 (18.13)	.98	.381	.03

Note. TD: typically developing, LL: low language, DLD: developmental language disorder. All data is raw data other than gesture rate which is number of gestures per 100 words. Different superscripts within the same row indicate differences between group means that are significant at p < .05

Gesture types

Table 4 demonstrates that parents produced predominantly representational gestures during both tasks. However, parents used proportionately more representational gestures during the narrative recall task than the referential task, F(1,54) = 115.99, p =.001, d =1.7, in which parents used a more varied gesture repertoire.

Table 4.

Mean proportion (SD) of gesture types produced during each task.

Gesture Type	Representational	Deictic	Conventional	Beat
Narrative Task	94.00 (9.70)	1.18 (2.50)	3.42 (6.96)	1.06 (3.31)
Referential Task	60.90 (25.53)	16.31 (14. 04)	20.54 (23.50)	1.91 (4.05)

Parent gesture use: Differences in task demands and children's language ability.

Parents produced gesture at a higher rate during narrative recall (M = 8.02, SD = 3.83) than referential communication (M = 4.03, SD = 2.23), F(1,56) = 77.42, p = <.001 d = 1.27. As predicted, there was a significant interaction between group and task, F(2,56) = 3.42, p=.040, η_p^2 =.11. Planned comparisons indicated that there were no significant group differences in the rate at which parents produced gestures in the narrative task, F(2,57) =. 8, p =.56, η_p^2 = .02 (Figure 3). In contrast, there were significant group differences in referential communication, F(2,56) = 5.17, p = .009, η_p^2 =.16. In this condition, parents of children in the TD group gestured less frequently than parents of children with DLD (p = .007, d = 1.01). The difference between parents of children in

the TD group and parents of children with LL was not statistically significant, though

the mean difference was of a large effect ($p = .093$, $d = .90$). There were no differences

in gesture rate between parents of children with LL or DLD ($p = .955$, $d = .14$). The

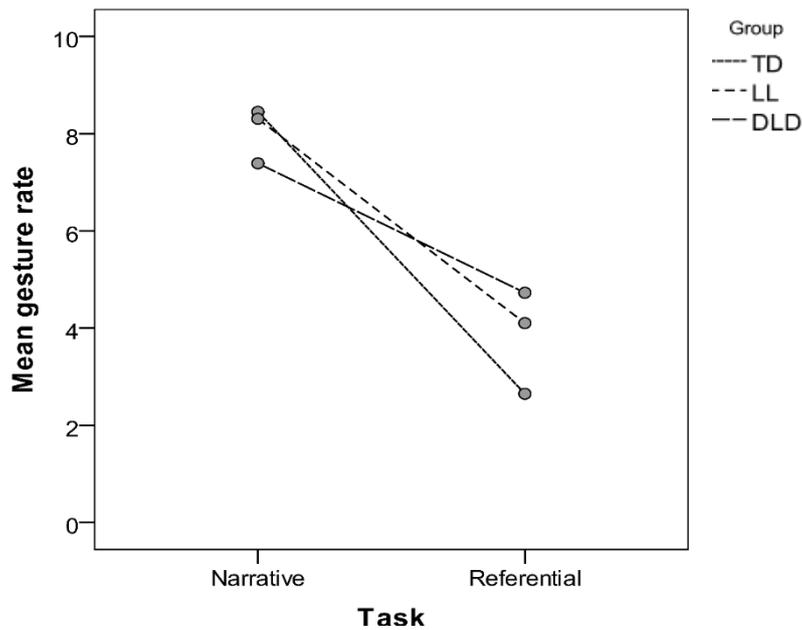main effect of group was not significant, $F(2,56)= .47$, $p=.629$, $\eta_p^2 =.02$.

Figure 3. Interaction between gesture frequencies across both tasks, by language group.

Parent gesture use: gesture function

In general, all parents used gesture to reinforce their spoken message, as indicated by

the large proportion of redundant gestures across both tasks (Table 5). Overall, there

was a significant main effect of task, $F(1,54)=17.14$, $p<.001$, $\eta_p^2=.24$, as parents

produced proportionately more extending gestures during referential communication

than during narrative recall. There was no significant main effect of group,

$F(2,54)=1.73$, $p=.186$, $\eta_p^2=.06$, nor a significant task x group interaction $F(2,54)=2.05$, $p=.138$, $\eta_p^2=.07$.

Table 5.

Mean (SD) proportion of extending and redundant gestures used during each task.

Measure	Gesture Function	Whole Sample	TD	LL	DLD
Narrative	Redundant	91.96	92.37	90.82	92.77
		(9.81)	(11.06)	(7.99)	(10.70)
	Extending	8.04	7.63	9.18	7.23
		(9.81)	(11.06)	(7.99)	(10.70)
Referential	Redundant	84.64	90.05	81.55	83.11
		(13.19)	(8.27)	(12.95)	(15.77)
	Extending	15.36	9.95	18.45	16.89
		(13.19)	(8.27)	(12.95)	(15.77)

Note: TD: typically developing, LL: low language, DLD: developmental language disorder.

Relationships between parent gesture, child gesture and child language (vocabulary)

For this analysis, groups were analysed together and for the referential task across the whole task (total of describer and listener roles). As illustrated in Figure 4a, there was a small but significant positive relationship between parent gesture rate and child gesture rate during interaction, ($r(58) = .39$, $p = .002$), that was apparent in all three language groups. However, there was a significant negative correlation between child vocabulary

and both child gesture rate ($r(58) = -.32$, $p = .015$) and parent gesture rate ($r(59) = -.42$, $p = .001$) during the referential communication task (Figure 4b). This indicates that parents of children with poorer vocabulary tended to gesture more frequently, but only during parent-child interaction.

Child gesture associations with parent language

As illustrated by Figure 4c, there was a significant, positive association between the number of extending gestures children produced and the number of words parents produced during the referential communication task, $r(59)=.39$, $p=.002$. This indicates that children who used gesture to convey information not realised in their verbal language elicited more verbal responses from their parents.
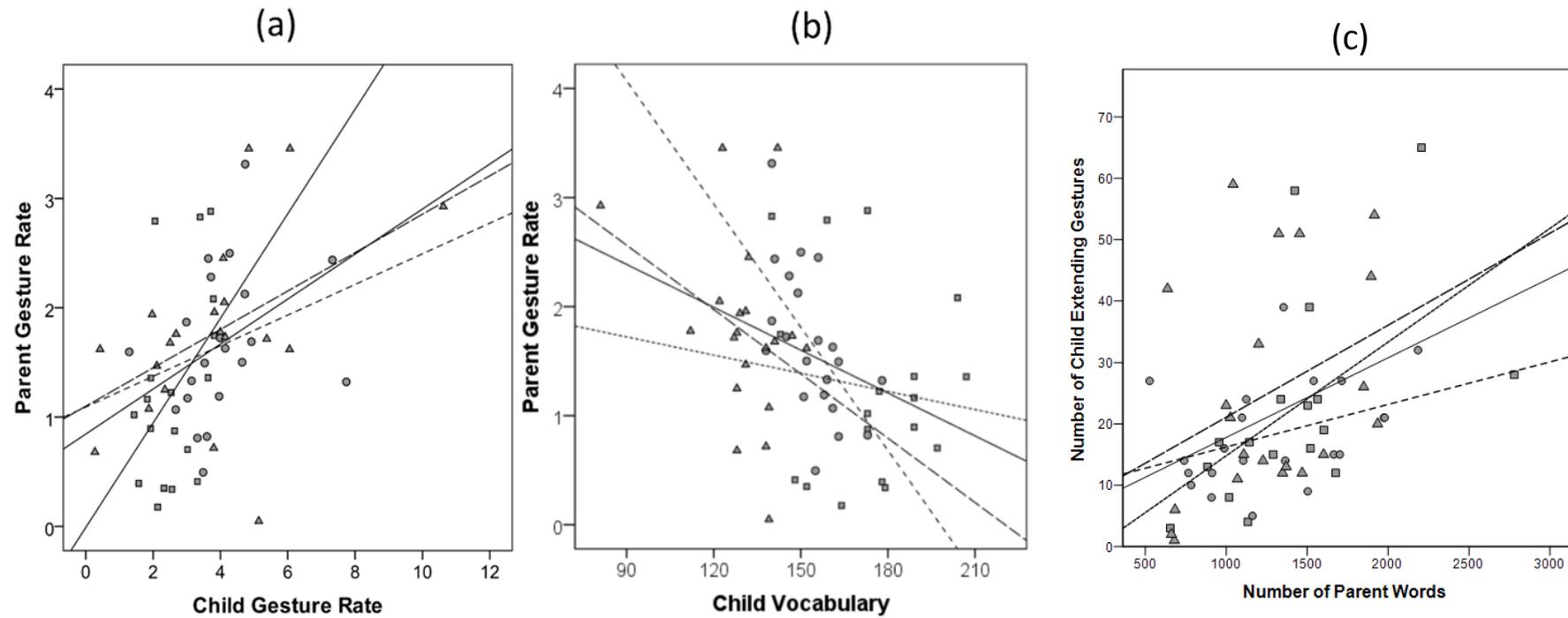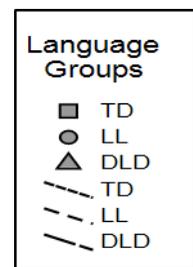
Figure 4. Scatterplots showing the relationships between (a) parent gesture child gesture, (b) parent gesture and child vocabulary and (c) children's extending gestures and parent language.

Discussion

This paper investigated the frequency of parent gestures in both a narrative monologue task and an interactive problem solving task and considered the extent to which parents adapted their use of gesture to differing task demands and their child's language competence. Our key findings are that parents of children with DLD gestured at a significantly higher rate than parents of TD children, but only during an interactive problem solving task. The function of parent gestures also differed across the two tasks; more redundant gestures were produced in the narrative task and more extending gestures were produced during the interactive task for parents across all three language groups. In addition, parent gesture rate during the referential communication task was positively correlated with child gesture rate, but negatively correlated with child vocabulary. Finally, children's use of extending gestures was positively associated with the number of words produced by parents during the referential task. We consider the implications of these findings in relation to each of our stated research aims below.

Do parents modify gesture use depending on their child's language ability and/or task demands?

Few studies have considered the role of parent gesture in atypical language development. The present study confirmed our initial hypothesis that parents of children with DLD would gesture more frequently than parents of TD peers. However, this difference was only significant in a task that involved interactive problem solving, where successful communication was key to accomplishing the task. A second novel finding is that whilst the LL children appeared to have intermediate language scores, on key gesture tasks their parents resembled parents of children with more significant

language needs. It is likely that many children in the LL group have resolved early language delays; if so, our findings are consistent with Grimminger et al. (2010) who reported that parents of children with language delay gesture more frequently than parents of TD children during complex tasks.

At first glance, these findings appear to contradict Lavelli et al. (2015) who found no significant group differences in parental gesture rate, regardless of child language status. However, Lavelli et al. (2015) do report a trend for parents of children with DLD to gesture at a higher rate than parents of TD peers. Also, they reported that parents of children with DLD produced more utterances that combined gesture and speech than parents of TD children, suggesting that parents were using gesture as an additional communication strategy to enhance verbal communication. One explanation for the disparity in findings is the contexts in which gesture was measured. Lavelli et al. (2015) measured gesture during shared book reading, whereas the current study used a more complex goal orientated task. The current study indicates that task demands may influence how frequently parents use gesture with their children, especially if their children have language and communication difficulties.

Consistent with previous studies of TD children and their parents, we found that parents of all three language groups produced gestures that predominantly reinforced the verbal message (Iverson et al., 1999; Özçaliskan & Goldin-Meadow, 2005). Such gestures are thought to support a child's understanding of their spoken utterance by representing information in dual modalities, highlighting salient information and focusing attention (Iverson et al., 1999). Taken together, these findings indicate that parents are sensitive to their child's language needs and adapt their behaviour

accordingly, but that knowledge of their child's communication strengths and weaknesses increases use of gesture in a compensatory way.

In the current study, parents used proportionately more redundant gestures during narrative recall relative to referential communication, during which more extending gestures were used. In addition, there was a trend for parents of LL and DLD children to produce proportionately more extending gestures during the referential communication task than parents of TD children (cf. Grimminger et al. 2010). This suggests that gesture may be employed for different purposes in each task. During narrative recall, gesture may serve to highlight salient information, reinforce the verbal message, and increase the child's attention and engagement by making the story more animated. Conversely, the referential task was a more complex, interactive task in which parents and children must successfully communicate to achieve their goal. As such, parents may adopt extending gestures as a means to support communication and facilitate the completion of the task when more complex communication is required and when they are able to receive direct feedback from their child that verbal communication has not been effective. As research highlights that information presented in two modalities improves children's ability to understand complex instructions (Church, Ayman-Nolley, & Mahootian, 2004; Cook & Goldin-Meadow, 2006; Cook, Mitchell, & Goldin-Meadow, 2008; Goldin-Meadow, Cook, & Mitchell, 2009), in the context of the referential communication task, parent extending gestures may have served to "lighten the cognitive load" for their child (Goldin-Meadow, Nusbaum, Kelly, & Wagner, 2001). This is achieved by providing children with additional non-verbal semantic cues and thus reducing linguistic demands; a communication strategy which may have helped facilitate task completion for those

children whose processing resources may otherwise have been devoted to linguistic

processing. However, in order to fully test this theory we would need to determine

experimentally whether task success is improved when parents utilise extending

gestures as a communication strategy.

Are the relationships between parent gesture and child gesture and child language

similar across different language ability groups?

In the current study, parents who gestured more frequently tended to have children who

gestured frequently, a pattern seen across all three language groups. This is consistent

with a body of research documenting parent-child gesture relationships in much

younger TD children (Iverson et al., 1999; Rowe & Goldin-Meadow, 2009a; Rowe et

al., 2008; Tomasello & Farrar, 1986). Our findings suggest that children with DLD are

as able as TD peers to observe parents using gesture to communicate and to adopt that

strategy themselves. Importantly, increased child gestures was also associated with

more severe child language impairment. Thus, children with limited verbal skills

nevertheless adopt gesture as a useful communicative tool.

A different relationship, however, was observed between parent gesture and

child language. During the interactive problem solving task, increased frequency of

parent gesture was associated with more severe child language (vocabulary)

impairment, partially supporting our initial predictions. Our findings are in line with

Lasky and Klopp (1982) who also reported a negative relationship between parental

non-verbal communication (facial expression, body posture, action, demonstration,

gesture and imitation) and child language ability. However, we did not observe a

positive relationship between parent gesture and child vocabulary within the TD group,

as expected based on extensive work with younger TD children (Iverson et al., 1999; Rowe & Goldin-Meadow, 2009a; Rowe et al., 2008). There are at least two reasons for this apparent inconsistency; first, previous studies have focused on early parent-toddler gesture and relationship to language skills in the pre-school years. With regard to age, our study is in line with Goodwyn et al. (2000), who experimentally manipulated parent gesture and found that the early observed advantages of parent gesture on child language ability at age 11 months did not persist at 6 month and 12 month follow-up visits. Together, these findings suggest that the relationship between parent gesture and child language may be most evident in the earliest stages of child language development before spoken language is established. Furthermore the findings could imply that in later childhood, parent gesture functions to facilitate communication rather than promote language acquisition (though see: Alamillo, Colletta, & Guidetti, 2013 and Colletta et al., 2015, for evidence of age related effects of gesture on oral discourse). Another explanation for the findings may be that the current study examined children with a wide range of language abilities and thus these findings may reflect differences in sampling rather than developmental changes. As gesture measures were only administered at one time point for the current study, this meant that it was not possible to look at changes in gesture over development, nor the long-term impact of parent gesture on children's language development. Longitudinal studies exploring parent gesture throughout childhood with children of varying language abilities would help to clarify whether the findings are due to developmental changes, or variability in children's language and help us to understand the extent to which parents can use gesture to support their child's language development in later childhood.

A second reason for discrepant findings may be that different indices of parent gesture employed in different studies. For example, studies with infants have measured gesture by the total number of gestures, focused exclusively on deictic gestures, or gesture vocabulary (defined as number of different gestures) (Iverson et al., 1999; Rowe & Goldin-Meadow, 2009a; Rowe et al., 2008). Whereas, the current study and studies of older children (Lavelli et al., 2015) have typically used gesture frequency (number of gestures per 100 words or number of gestures per minute) as the dependent variable. It is possible that different gesture metrics relate to language in different ways. Due to the limited language of young children it would be difficult to measure gesture frequency with infants. However, future research could explore gesture vocabulary in school-aged children to determine whether this aspect of gesture is more closely linked to language development.

Are child gestures associated with the amount of verbal language parents provide?

Studies of TD children have indicated that the role of parent gesture on child language is indirect, exerting an influence on language development through its effects on child gesture (Rowe et al., 2008). A puzzle for researchers then has been to understand the mechanisms through which child gesture acts on child language development. An influential theory has been that child gesture matters because it elicits responses from parents that provide verbal labels for the concepts and structures that children are attempting to convey through gesture (Goldin-Meadow et al., 2007). In the current study, we asked whether increased use of child extending gestures, or gestures in isolation would elicit more verbal information from parents. Like deictic gestures, extending and isolated gestures involve gestures for which the verbal equivalent is not produced. Furthermore, extending gestures allow children to produce more syntactically

complex utterances (Stefanini, Caselli, & Volterra, 2007), something which might be particularly challenging for children with DLD. Indeed, we did observe significant positive correlations between the number of child extending gestures and the total number of words that parents provided. These findings suggest a reciprocal relationship in which parent gesture reflects the child's language learning needs, but child gestures signal to parents more specifically what those learning needs may be. However, this may be dependent on parent's ability to recognise children's gestures and provide appropriate verbal feedback. As such, parent-focused interventions aimed at encouraging parents to not only gesture but also to attend and respond appropriately to gestural information may serve to facilitate communication and language development. Further investigation into this relationship could determine how semantically contingent parents' verbal responses are to their child's extending gestures, something that we are currently investigating.

Our findings with children of varying language abilities echo earlier findings, which suggest that parent gesture signals to children that gesture is a useful communication strategy, and that the verbal responses of parents to child gesture fill in linguistic gaps, which in turn may help to drive language development, particularly in the early stages of language growth and when language learning is more challenging. Future longitudinal studies exploring gesture and language input in the same cohort of children across childhood would help us to fully investigate the impact of parental input on children's language development across the lifespan.

Summary and conclusions

Our findings indicate that at this age and with a diverse group of language learners, parent gesture is as much driven by the child's language needs as it is driving child language development. Similarly, the relationships we see indicate that all children, including those with DLD and LL, may use gesture to elicit verbal messages from their parents. It is worth highlighting that our study clearly shows that parents of children with DLD use gesture to the same extent (if not more) than TD parents, and are sensitive to their children's language learning needs. In this population, gestures serve to maximise communication success that may be compromised by oral language weaknesses. Thus, increased use of gesture is most evident when communicative demands are high and parents are sensitive to their child's communication challenges. When necessary, supporting parents to recognise a child's communicative attempts in gesture, and providing appropriate verbal labels to reinforce the gestures, may be a powerful tool in continuing to develop language skills in children with DLD.

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