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Parental input to children with ASD and its influence on later language

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Language development is variable even in the typical case, but the majority of children begin to comprehend single words between 9- to 12-months and produce their first words between 12- to 15-months of age (MacArthur-Bates Communicative Development Inventories; Fenson et al., 2007). When evaluated as a group, toddlers with Autism Spectrum Disorder (ASD) exhibit delays in early language development (e.g., Anderson et al., 2007; Weismer, Lord & Esler, 2010). For example, whereas 50% of typically developing (TD) children label objects at 14 months, only 15% of children with ASD did so by 2 years of age (Luyster et al., 2007). In the context of this group-level delay there is enormous individual variability in language skills among children with ASD. Kjelgaard & Tager-Flusberg (2001) found that by school age approximately half of children with ASD had impaired language as assessed by standardized tests, a quarter had borderline skills within two standard deviations of the normal range, and the last quarter scored in the normal range or above. Notably, a minority of children with ASD perform as well as TD peers on standardized tests (Kjelgaard & Tager-Flusberg, 2001; Luyster et al., 2007). The first finding of delayed vocabulary as a group is commonly acknowledged, while the second point about variability within the autism spectrum has received relatively little attention in the fields of language development and developmental psychology.

In contemporary work language development is often construed in an interactionist framework involving the dyadic interaction of *nature* and *nurture* components (Chapman, 2002). Much of what we know about language development and impairment in ASD falls on the *nature* side of the puzzle. ASD is a complex neurodevelopmental condition involving differences in genetics, in neural structure and function, and in learning mechanisms as well as attentional preferences, all of which in turn impact language development (Bourguignon, Nadig & Valois, 2012). As just noted, in many, but not all, cases of ASD this results in early language delay. We

also know of important *nature*-related predictors of better language outcomes in ASD: Nonverbal IQ and social communication skills (e.g., gestures, pointing to objects of interest) are strong predictors of concurrent and later language ability (Anderson et al., 2007; Luyster et al., 2008). School-age vocabulary skills have even been shown to predict linguistic functioning in adulthood (Mawhood, Howlin, & Rutter, 2000). Essentially, the more language children have the more they can learn, but beyond having the good fortune of coming equipped with high nonverbal IQ or strong social communication skills, what factors can shape the course of language learning in ASD? In this chapter we synthesize work on the *nurture* side of the puzzle: First, what does the language learning environment available to children with ASD, through their caregivers' language input, look like relative to that of TD children? Second, crucially, is there evidence that children with ASD are able to use language input to facilitate language development? If so, differences in input may help us explain part of the tremendous variability observed in trajectories of language development in this population.

We know from wealth of evidence over the past 40 years that the *nurture* side of the puzzle, as indexed by more and varied language input, enhances TD language development, which in turn confers long-term linguistic and academic advantages. Hart & Risley (1995) reported extreme differences in amount of interaction and language input children of different socioeconomic status receive. In their study, children from poorer backgrounds heard 30 million fewer words by age 3 than children with professional parents, and the latter had better academic outcomes at age 9 (Hart & Risley, 1995). Even among parents who have similar education levels, variation in the overall number of words parents speak has been shown to be related to their children's rate of vocabulary development (Huttenlocher et al., 1991) and the speed of their later vocabulary processing (Hurtado et al., 2008). Moreover, lexical richness as measured by the

number of word types (different words) in the input, and syntactic complexity as measured by MLU, are predictive of children's later vocabulary size (Hoff & Naigles, 2002). These findings reveal that children implicitly keep track of language input, and develop better language abilities when immersed in rich input environments. Recently this body of research has been in the public spotlight, galvanizing campaigns in the US that encourage parents to read, talk, and sing to their kids to "close the word gap" or decrease disparities normally experienced by underprivileged groups, for instance Providence talks http://www.providencetalks.org/ and Too small to fail http://toosmall.org/ .

There has been less attention paid to the *nurture* side of the language development puzzle in ASD. A historical reason for this is the psychoanalytic account of ASD, dominant in the mid-20th century, which inaccurately and tragically blamed parents for their children's autism (e.g., "Refrigerator mother theory;" Bettelheim, 1967). While sensitivity should be exercised in any reporting on parent behaviour with respect to children with ASD, this legacy should not preclude the advancement of a line of research that has been very fruitful in understanding the full scope of factors contributing to language development in TD children. Another reason why there has been less research on the *nurture* side includes the simple fact that, especially under earlier diagnostic classifications, children with ASD had significant language delays and thereby did not appear to benefit from language input in the same way as TD children. Finally, given that reduced early social attention is a defining feature of ASD, and that subgroups of young children with ASD show reduced attention to child-directed speech (Kuhl, Coffey-Corina, Padden and Dawson, 2005), learning from the input was not necessarily expected. However, the substantial individual differences in language development among children currently identified with ASD begs examination of *nurture* as well as *nature* contributions to language development. A clearer

picture of the data that children with ASD have available to mine for language learning, as well as of specific relationships between aspects of the input and later language development, are essential for a comprehensive view of factors that contribute to language development in this population. This line of study also holds promise for improving language outcomes. For instance, if children with ASD are found to benefit from lexically- and syntactically-rich language input as TD children do, their language can be improved by exploiting the *nurture* side of the puzzle (e.g., strategically modifying the input they receive) in cases where *nature* does not pave the way for optimal language development (e.g., Yoder, Spruytenburg, Edwards, & Davies, 1995; see also McDuffie et al., this volume).

Before considering these questions, we raise the key methodological issue of matching criteria as it impacts the interpretation of parental input data. Since children with ASD exhibit language delay as a group, if they are compared to same age TD peers they will have significantly lower language skills, especially at early stages of development. Parental input is sampled from situations of parent-child interaction which are inherently dyadic in nature; parents initiate topics and comments but also increasingly respond to their child's initiations and questions as the child's communicative repertoire grows. We know that parents tailor their input to their child's language level in multiple ways (Snow, 1995), for example, adjusting syntactic complexity as measured by MLU (Konstantareas, Zajdeman and Homatidis, 1988), or the amount of acoustic modification used in infant-directed speech (Kitamura & Burnham, 2003). Unlike strangers, parents are perhaps especially skilled at language-level "tuning" as they have a privileged window on their child's comprehension abilities through ongoing interactions (Sokolov, 1993). The practice of ***matching groups on child language level***, which dominates the literature, allows for an examination of *how parental input to children with ASD vs. typical*

development compares when the child's side of the exchange is controlled. In contrast, **matching on child chronological age** addresses the question of *how the language delay present in the sample with ASD impacts parental input at a given maturational point*. These matching strategies provide complementary information on the language environment available to children with ASD, but the former teases apart whether any potential differences are due to ASD rather than its associated language delay. Another important way to examine whether differences are specific to ASD or shared with other language-delayed populations is to compare across children with ASD and those with non-ASD developmental delays. This is particularly informative because both chronological age and language level can be methodologically controlled at once.

In this chapter we review evidence on parental input to children with ASD, moving from quantitative measures of linguistic features to qualitative measures of interaction. First we examine *lexical and syntactic features* (e.g., number of utterances, MLU) in the input provided to children with ASD compared with TD children matched on language level. Second we turn to work on *parental responsiveness*, or the tendency to provide verbal or gestural input in sync with the child's focus of attention, and how this compares across dyads including a child with ASD or a TD child. We also review findings on specific *functions of parental responsive utterances* and evaluate the impact these input features have on later child language in ASD. Finally, to provide a complete picture of the current state of the *nurture* side of the puzzle, we review findings on multiple *other aspects and contexts of parental input* where preliminary data is available. We conclude with a discussion of the pattern of striking similarities observed between groups for many of these features, what the differences found point to, and how these findings inform our understanding of the *nurture* side of language development in ASD.

Lexical and Syntactic Features of Parental Input

Children are exposed to numerous features of spoken language in their language-learning environment. Some commonly examined features include measures of lexical information such as the number of utterances, number of word tokens, and number of word types, as well as grammatical information such as mean length of an utterance (MLU) and the use of *wh*-questions. This section reviews findings on lexical and grammatical input provided by parents to their children with ASD, compared to parents speaking to their children with TD, when *dyads are matched on child language level* (i.e., often vocabulary scores from parent-report measures or spoken vocabulary during the parent-child interaction). The mean age of children with ASD in these studies was approximately 40 - 50 months old, the mean age of TD children was approximately 20 - 30 months old, and sample sizes ranged from 10 – 24 children per group (one exception is Watson et al., 2010 who included 78 TD children). Additionally, studies have also matched groups on variables of child gender and socioeconomic status, usually as measured by level of maternal education. The large majority of these studies have examined parental input during parent-child free play interactions (9 to 30 minutes) in the laboratory or at the family's home.

Number of utterances. Spoken language is divided into segments of speech termed *utterances*, which are delineated by a noticeable pause break or intonational markers such as rising pitch for questions. The total number of utterances provides a global measure of the quantity of parent talk. The large majority of studies have not found significant differences in the number of utterances spoken between parents of children with ASD and parents of TD children (Bang & Nadig, 2015; Goodwin, Fein, & Naigles, 2015; Watson, 1998, Wolchik & Harris, 1982; but see Wolchik, 1983).

Other lexical features. When words are strung together, for example "*The black dog*

chews the bone'', we can extract different types of lexical information. For instance, we can count the *word tokens* (the total number of words spoken, which is 6 in this case), the *word types* (the total number of different words (NDW) spoken, 5 in this example), and the *lexical diversity* of the utterance (a measure of the number of different words out of the total number of words, which would be 5/6 using a simple type/token ratio). We can also examine how parents use individual words. *Word frequency* refers to the number of times a word is spoken and *contextual diversity* refers to the number of unique words that appear before and after a target word (Hills, Maouene, Riordan, & Smith, 2010). For example, in the phrase above the word frequency of *dog* is 1 and the contextual diversity of *dog* is 5 because there are two words before *dog* that each appear once (*the, black*) and 3 words after *dog* that each appear once (*chews, the, bone).*

Studies that have examined lexical features of parent input have not found significant differences between mothers of children with ASD and mothers of TD children with respect to word tokens, word types, or lexical diversity measures (Bang & Nadig, 2015; Slaughter et al., 2007; Swensen, 2007; but see Warren et al., 2010 for a different perspective). Swensen (2007) found no significant differences between mothers of children with ASD and mothers of TD children on word types, noun types, and the percentage of different nouns. In the only study examining lexical features of parent input to children with ASD in a language other than English, Bang and Nadig (2015) matched English-speaking and French-speaking mother-child dyads with children with ASD or TD children. No significant differences were found between diagnostic groups in both English-speaking and French-speaking families during a free play interaction on maternal word tokens, word types, and lexical diversity. Table 1 compares the 10 most frequent words in the corpora and demonstrates that mothers of children with ASD and mothers of TD children also used individual words similarly during the free play interaction (Bang & Nadig,

2012). Figure 1 presents scatterplots of the contextual diversity values for individual words in our corpora spoken by mothers of children with ASD versus mothers of TD children. The plots demonstrate strong correlations between groups in both English and French; that is, the same words were spoken in few or many contexts across diagnostic groups. Current work in our lab aims to examine the influence of word frequency and contextual diversity on children's acquisition of individual words, as seen in typical development (Hills et al., 2010; Huttenlocher et al., 1991).

MLU. We can also extract syntactic information from a speech sample. As previously observed for lexical features of the input, studies have unanimously found no significant differences between dyads with a child with ASD or a TD child with respect to parental MLU (Bang & Nadig, 2015; Goodwin, Fein, & Naigles, 2015; Swensen, Naigles, & Fein, 2007; Wolchik & Harris, 1982; Wolchik, 1983).

Questions. Another way syntactic complexity has been studied is through the analysis of the type of questions parents ask their children, specifically *yes-or-no* questions (e.g., do you have the train?) and *wh*-questions (e.g., who, what, when, where, why). *Yes-or-no* and *wh*-questions are syntactically advanced constructions because they 1) deviate from the standard word order of English (i.e., they are in the less frequent SOV order: subject, object, verb), and 2) highlight the use of auxiliary verbs which express tense and mood (e.g., do, can and will). One study examined the use of *yes-or-no* questions during free play and found no differences between parents of children with and without ASD (Swensen, 2007), however findings on *wh*-questions have been mixed. Whereas no significant differences were reported in early investigations of *wh*-questions (Wolchik, 1983; Wolchik & Harris, 1982), Goodwin, Fein, & Naigles (2015, see Naigles & Fein this volume) conducted a comprehensive examination of *wh*-question types and

found that mothers of children with ASD produced a significantly lower percentage of *wh*-questions and less varied *wh*-questions than TD children. This discrepancy in findings may be linked to the particular constructions studied, e.g., those that are simple and repetitive versus syntactically complex.

Finally, one study has examined parental input to different groups of children on the autism spectrum. Konstantareas, Zajdeman and Homatidis (1988) compared maternal input from mothers with high-functioning children with ASD with that of mothers of low-functioning children with ASD (language age approximately 12 months) matched on children's chronological age, gender, and socioeconomic status. No significant differences were found between groups on the number of utterances spoken by mothers, but, not surprisingly, mothers of high-functioning children produced more syntactically complex input (i.e., longer MLUs). This supports the idea that parents provide input that is calibrated to their children's language abilities, a point that will be returned to in the discussion.

In sum, a growing body of literature comparing parent input to children with ASD or to language-matched TD children demonstrates that parents produce strikingly similar linguistic environments in both cases, albeit at a substantial delay for most children with ASD due to their language proficiency. Other studies comparing parent-child dyads of children with ASD and DD children also did not find significant differences between groups when children were matched on language level (Cantwell, Baker, Rutter, 1977; Venuti, de Falco, Esposito, Zaninelli, & Bornstein, 2012). Conversely, one area of possible difference between ASD and language-matched TD groups is in the use of *wh*-questions, which were decreased in input to children with ASD (Goodwin, Fein & Naigles, 2015). Importantly the use of questions impacts child syntactic development, as discussed below and in Naigles & Fein, this volume.

Impact of Lexical and Syntactic Features on Later Child Language

An overview of the linguistic input available to children with ASD presents a consistent picture that lexical and most syntactic features of maternal speech input studied to date are similar for children with ASD and TD children. However, even if the linguistic environment is rich with information, the critical next step is to assess whether children with ASD are able to use this information to support their later language as has been demonstrated in TD children (e.g., Hoff & Naigles, 2002; Huttenlocher et al., 1991).

Frank et al. (1976) first reported a significant positive correlation between *concurrent* maternal and child MLU. Recent studies have shown that multiple features of the input are positively and significantly correlated with *later* child language. Warren and colleagues (2010) demonstrated significant positive correlations between input number of word tokens and children's later vocabulary production. Swensen (2007) explored multiple correlations (see **Other lexical features** section for details on methodology) and found that the number of maternal noun types were positively and significantly correlated with child vocabulary production 4 months later as measured by number of word types and 8 months later as measured by the MCDI. Maternal use of *yes-or-no* questions was positively and significantly correlated with children's production of auxiliary verbs 4 months later. Partial correlations taking into account maternal IQ or child language abilities demonstrated similar relationships. These findings demonstrate a direct positive association in ASD between specific linguistic information in maternal input and children's later language production of related features.

Other studies employing multiple regression have also demonstrated that, after controlling for children's initial language abilities, maternal input features significantly account for variation in children's later language (Bang & Nadig, 2015; Goodwin et al., 2015). As

discussed in more detail in Naigles & Fein (this volume), Goodwin and colleagues found that for

both ASD and TD groups the percentage of input *wh*-questions with verbs positively contributed

to children's later *wh*-comprehension over and above maternal (MLU) and child language

abilities (word types). However, measures of specific types of *wh*- questions displayed divergent

relationships across groups with respect to child language one year later.

To directly compare the relationship between maternal input features and later child

language between children with ASD and TD children, Bang and Nadig (2015) employed one

hierarchical multiple regression model to investigate the contribution of maternal input MLU to

children's vocabulary production 6 months later (as measured by the MCDI), over and above

children's initial language abilities. Figure 2 visualizes the key finding that input MLU positively

accounted for 8% of the variation in children's later vocabulary production. The finding that

MLU was a positive predictor across both groups of children and a lack of a significant

interaction between input MLU and diagnostic group indicates that this effect is not significantly

different between groups, meaning that in both children with ASD and TD children, MLU

contributed positively to their vocabulary development over 6 months.

To return to the goals of this review, we have established that on most quantitative

measures of linguistic input the language environment available to children with ASD is

strikingly similar to that of TD children who are matched on language ability. Crucially, we also

have evidence that children with ASD are able to make use of the linguistic input (e.g., word

tokens, MLU, *yes-no* and *wh*-questions) to enhance their language development; this finding is

of key clinical importance for improving language outcomes. Taken together, these conclusions

suggest that the language delays observed in ASD do not stem from categorical differences on

the *nurture* side of the puzzle, either with respect to differences in parental input, nor, on the

nature side of the puzzle, to children's inability to make implicit use of the data in the input. On the other hand, significant relationships between linguistic input features and later child language do provide a partial *nurture*-related explanation for the tremendous variability observed in language development across children with ASD: variation in relevant parent input features. To complement findings on linguistic features, we now turn to research on parental responsiveness during parent-child interactions. Although quantitative measures of linguistic features were found to be quite similar across groups, qualitative measures of responsiveness may be more likely to be affected by the social impairments that characterize ASD.

Parental responsiveness

Studies on typical development have reported on the linguistic benefits conferred by not only the quantity and content of parental speech, but also the *quality* of how it is delivered (see Hoff & Naigles, 2002 for a review). Following the child's lead or following into a child's focus of attention (hereby *parental responsiveness*) refers to parents' provision of verbal or gestural input contingent on the object or event currently holding their child's attention; importantly in these situations the parent assumes the task of establishing joint attention. Children with ASD have difficulty tracking others' attention (e.g., Mundy, Sigman, & Kasari, 1990); consequently, following the child's attentional focus is a central component of many parent-training interventions (see McDuffie et al., this volume).

Comparisons between parents of children with ASD and parents of TD children reveal similar levels of parental verbal or gestural responsiveness (Bani Hani, Gonzalez-Barrero, & Nadig, 2012; Burns, 2012; Kasari, Sigman, Mundy, & Yirmiya, 1988; Siller & Sigman, 2002; Watson, 1998), and similar abilities to sustain periods of mutual engagement with their child (Adamson, Bakeman, Deckner, & Romski, 2009; Kasari et al., 1988). For example, Siller &

Sigman (2002) found no significant group differences in mothers' verbal and gestural responsiveness, also referred to as maternal synchrony. Recent work from our lab replicates this basic finding. Burns (2012) found no group differences in parents' production of object labels that were synchronous with their child's focus of attention during play. In a different type of interaction, Bani Hani et al. (2012) investigated parental use of verbal and gestural cues when teaching children novel labels for objects. Again, no differences were found between groups in synchrony between parents' utterance of the label and children's attention to the object. Likewise, studies that compared children with ASD with children with non-ASD developmental delays did not find group differences (Adamson et al., 2009; Cantwell et al., 1977; Kasari et al., 1988; Siller & Sigman, 2002). However, a few specific differences have been observed. For instance, parents of children with ASD produce more out-of-focus utterances to guide their child's behavior (Watson, 1998), and parents of children with ASD provide more positive feedback than parents of TD children (Kasari et al., 1988) and parents of children with non-ASD developmental delays (Cantwell et al., 1977).

Overall, these findings indicate that parents interacting with their children with ASD are as verbally and gesturally responsive as parents interacting with TD children or DD children, but also provide significantly more positive remarks or behavioral guidance to their children. This suggests that parents of children with ASD may need to do extra work to structure and maintain the interaction to achieve the same level of engagement. The next section details how parental responsiveness measures are related to later child language.

Impact of Parental Responsiveness on Later Child Language

Siller and Sigman (2002) were the first to examine long-term effects of parental verbal and gestural responsiveness on child language at multiple time points in children with ASD.

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Although there were no significant associations with 1-year language gains, maternal synchrony for verbal utterances overall was significantly and positively correlated with language gain at 10 years. In another sample of children with ASD, Siller & Sigman (2008) employed multilevel modeling analyses to reveal maternal synchrony measures of verbal and gestural responsiveness predicted children's rate of language growth over a period of 4 years. In both studies, these findings were independent of children's language and IQ scores, which suggests that these relationships were not spurious results driven by children's own level of functioning. These findings underscore the importance of parental responsiveness to support the later language of children with ASD; similar positive relationships have been found for sustained periods of engagement (Adamson et al., 2009). Notably, there is evidence that parent training programs are successful at increasing parent responsiveness (McDuffie et al., this volume; Roberts & Kaiser, 2011), indicating that it is possible to boost this consequential *nurture* factor. Researchers have also begun to tease apart the different *functions* served by parental responsive utterances and their specific contributions to children's later language (Haebig, McDuffie, & Weismer, 2013a; 2013b; McDuffie & Yoder, 2010; Rollins & Snow, 1998).

Function of Parental Responsive Utterances

There are many different ways to classify the function of responsive verbal utterances. For example, if a child is playing with a toy truck the parent could ask a question ("Where are you going with the truck?"), direct the child's language or behavior (i.e., *follow-in directives* such as "Push the truck to me!"), or comment on the child's attentional focus (i.e., *follow-in comments* such as "That's a bright red truck!; McDuffie & Yoder, 2010; Haebig et al., 2013). Studies comparing the function of parental responsive utterances between parents of children with ASD and parents of TD children have again found no significant differences (Wolchik

1982, 1983; Siller & Sigman, 2002). Walton and Ingersoll (2015) used a detailed micro-analysis and found that follow-in directives more often preceded children's language than follow-in comments for both children with ASD and TD children.

As noted above for linguistic features, the few differences that have been found occur when comparing mothers of children with high-functioning versus low-functioning ASD (Konstantareas et al., 1988). Whereas mothers of high-functioning verbal children provided more questions, answers to children's questions, reinforcements of children's language, and language modeling (i.e., repetition, expansion, correction of child's language), mothers of low-functioning non-verbal children provided more directives and reinforcements of children's motor behavior. These findings echo those of Kasari et al. (1988) where parents of high-functioning verbal children with ASD spent more time in mutual play and gave more positive feedback, and parents of low-functioning children with ASD provided more bids for attention, to initiate activities, and to hold them on task. These differences underscore once again how variability in child language ability and ensuing parental input inherently shapes their language environments, the *nurture* side of the puzzle.

Impact of Function of Parental Responsive Utterances on Later Child Language

Numerous studies have reported significant positive effects of follow-in comments, follow-in directives, and parent expansions on children's later language in ASD 6 months, 4 years, 10 years, and strikingly even up to 16 years later (McDuffie & Yoder, 2010; Siller & Sigman, 2002, 2008). Haebig and colleagues (2013a, 2013b) have also reported differences in the predictive power of follow-in comments versus follow-in directives for different subgroups of children with ASD. Whereas follow-in directives accounted for children's comprehension and production gains 1 year later (beyond follow-in comments and parent education levels), follow-

in comments demonstrated a *negative* relationship. Further analyses revealed that a positive

relationship was noted with follow-in comments for minimally verbal children (i.e., producing

fewer than 5 words) whereas the verbally fluent children did not benefit from follow-in

comments. A follow-up study 3 years later replicated these findings.

The findings reviewed in this section demonstrate that, as for quantitative linguistic

measures in the previous section, the quality of parental input as indexed by responsiveness has

significant positive effects on later child language in ASD above and beyond child language and

IQ. This adds another key player to the *nurture* side of the language development puzzle in ASD.

An important future direction is to compare the impact of both quantitative and qualitative

features longitudinally in the same sample of children with ASD, as well as to determine which

functions of responsive utterances benefit which subgroups of children with ASD (Haebig et al.

2013a, 2013b). We now turn to preliminary findings from other domains that can contribute to

the *nurture* side of the language development puzzle.

Other aspects and contexts of parental input

Diverse aspects of parental input to children with ASD have begun to be explored, from

the acoustic modifications of child-directed speech to parental input in the context of storybook

reading, including the production of internal state terms. We survey these findings below to paint

as broad and complete a picture as possible of parental input to children with ASD and to outline

productive areas for future work. In contrast to the evidence reviewed in the prior sections, a

number of these studies report group differences as well as some points of similarity.

Acoustic modification of child-directed speech.

In our lab we examined the acoustic modification of child-directed speech to children

with ASD using a book-reading task to elicit child-directed speech and an experimenter

interview about the content of the books to elicit adult-directed speech from parents. Participants were parent-child dyads who either had a child with ASD (*M* age 60 months) or a child with typical development (*M* age 30 months) matched on child vocabulary level. Individual words that a parent produced in both child- and adult- directed contexts were extracted from audio recordings of the session and analyzed for mean pitch, pitch range, and amplitude in each context. Parents in both groups demonstrated acoustic modifications characteristic of child-directed speech; they increased their pitch, pitch range and amplitude on words spoken in the child-directed context and there were no significant group differences (Flores, Burack & Nadig, 2011). Another group, Xu, Gilkerson, Richards, and Rosenberg (2012), compared toddlers of the same age but different language levels and analyzed large samples of parental speech to children vs. adults via ongoing recordings. These authors report that parents of toddlers with ASD produced significantly longer vowel duration, louder vowel volume, and higher vowel pitch than parents of TD toddlers. This discrepancy in findings may be explained by different matching procedures across studies. In the Xu et al. (2012) study the children with ASD had lower language levels than TD children, whereas in Flores et al. (2011) groups were matched on language level. Assuming that parents are sensitive to their child's language abilities when producing acoustic features of child-directed speech, it is not surprising that children at lower linguistic levels would receive more exaggerated child-directed speech than those at higher language levels. Future work should explore developmental changes in the production of child-directed speech to children with ASD in addition to confirming if differences observed are linked to child language ability rather than ASD per se.

Teaching novel labels.

Bani Hani, Gonzalez Barrero, and Nadig (2012) found similar behaviors in parents'

labeling of novel objects between parent-child dyads where there was a child with ASD vs. a TD child matched on language level. The number of labels parents produced and number of nonverbal cues they used did not differ across groups. In addition, the number of episodes where multiple cues were produced in conjunction with the label was similar, as was the tendency to provide the first label when the object was already in the child's focus of attention (about 90% of episodes for both groups). Finally, the mean number and type of nonverbal cues used (e.g., gaze to object, showing, movement) was very similar across groups. Interestingly, parents of both groups provided more abundant cues when labelling for children who had lower language levels, suggesting they are sensitive to their child's comprehension needs. However, exact tactics differed by group, with parents of children with ASD repeating verbal labels to children with lower language levels, perhaps to gain their attention, whereas parents of TD children tended to use multiple nonverbal cues (e.g., gaze to object, showing, movement). These findings are consistent with the findings reviewed above on similarities across groups in parental responsiveness during play interactions more generally.

Turn taking.

Warren and colleagues (2010) investigated language input from any adult in the environment to young children with ASD or to TD children who were similar in age (*M* age approximately 30 months) using automated analyses of large samples of continuously recorded speech. Recordings were processed with Language ENvironment Analysis (LENA) software, which uses an algorithm to segment sounds based on acoustic features into speech-related (i.e., speech, singing) and non-speechlike (i.e., laughing, burping) as well as identifying speakers as children or adults. As would be expected given the language delay common in ASD, they found significantly fewer and shorter child vocalizations in the ASD group. With this background there

were also fewer conversational turns between adults and the child in the ASD group. Finally, the speech of TD children was more likely to take place in conversations than monologues, whereas the reverse was found for children with ASD. To further examine the back and forth nature of parent-child interactions over time, this group compared the social feedback loop between adults present in the language environment and children with ASD or TD children (Warlaumont, Richards, Gilkerson, & Oller, 2014). Specifically they examined contingency of adults' responses to children's speech-related vocalizations, and of children's responses back to the adult. Over 13,000 hours of the language environment was recorded from 106 families with TD children and 77 families with children with ASD matched on child chronological age, gender and maternal education, but not child language ability. Warlaumont and colleagues replicated findings of fewer speech-related vocalizations by children with ASD relative to TD children, but found a social feedback loop to be statistically present for both groups of children: relative to chance, adult vocalizations were contingent to children's vocalizations, and children's vocalizations were more likely to be speech-related when an adult responded to the child's previous speech-related vocalization. However, the first contingency in the social feedback loop, that of adult responses to children, was significantly weaker for children with ASD than TD children.

This microanalysis is an important step towards understanding the reciprocity of parent-child interactions. The factors that lead to the weaker contingency observed in ASD are, however, an open question. Future work should examine the relative roles of parent vs. child, as well as the specifics of their conversational contributions in establishing contingency. For example, the content of utterances, which was not analyzed in this impressively large but linguistically underspecified dataset, are likely to be consequential. Additionally, though

children's own vocalizations were statistically adjusted for this does not provide the same control as matching groups on language ability. As discussed in the introduction, parents adapt to their child's language ability over time, thus comparison with TD children matched on language or a DD group would provide a clearer understanding of whether the weaker contingency observed here is specific to ASD or if it characterizes interactions with children of lower language level more generally.

Parental input in the context of shared storybook reading.

In our lab we have begun to examine the function of parent utterances in a context that is a particularly rich source of language input, shared storybook reading. Storybook reading differs from free play interactions, where most parental input data has been sampled, by being relatively more structured due to the presence of text and the goal of completing the book. We compared parental input to children with ASD (*M* age approximately 50 months) or TD children (*M* age 24 months) matched on receptive language. Parental speech was first categorized as reading of text, or additional speech that was either story-related (e.g., labelling, responding to the child's questions, elaborating on the story) or non-story related (managing behavior, getting the child's attention). Parents in both groups were similar in regard to proportion of speech that was read text or non-story related utterances; however significant differences were found in the use of story-related utterances. Specifically, parents of children with ASD produced significantly fewer story-related utterances: fewer questions, instances of labelling or requests for labels, and questions or statements relating the book to the child's own experience than did parents of typically developing children, resulting in a significantly lower total MLU (Smith & Nadig, 2012). Another analysis examined the types of questions parents produce during shared storybook reading found that parents of children with ASD asked fewer identifying questions

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(e.g., "Where is the mushroom man?") and *yes/no* questions ("Is mushroom man the pilot?") than did parents of TD children. Requests for labels (e.g., What is this?) did not differ between groups (Gonzalez-Barrero & Nadig, 2013). Analyses in progress examine whether frequency of book reading in the home and parental education level contribute to the differences found. This initial evidence indicates a prominent number of differences in input provided in the context of shared storybook reading, relative to the global picture of nearly identical input provided to children with ASD in free play and less structured home environments. It is possible that focus on reading text rather than engaging in additional exchanges about the story is related to the strong interest in text and strength in decoding often observed in children with ASD, alongside poor reading comprehension (Huemer & Mann, 2010; Nation et al., 2006).

Production of internal state terms.

Slaughter, Peterson & Mackintosh (2007) examined parental input during shared picture book reading with a focus on internal state terms. Participants were 4- to 9-year-old children with ASD and TD children matched on receptive vocabulary. Mothers of children with ASD and those of TD children produced narratives of similar length, similar numbers of word tokens, and did not differ with respect to the mention of cognition, affect, or perception/attention terms. However mothers of children with ASD provided significantly fewer clarifications or elaborations of the cognition and affect terms they used. That is, they were less likely to explicitly state the contents of characters' minds, include explanations of sources of knowledge, or note discrepancies either between different characters' mental states or between these and physical reality (Slaughter, Peterson & Mackintosh, 2007). In partial correlations controlling for verbal mental age, maternal education and maternal verbosity, mention and clarification of cognition terms was associated with false belief performance in TD children, but only

clarification of affect was related to false belief performance in the ASD group.

This suggests that parents are as likely to mention mental states in their speech to children with ASD; however, differences in the *nurture* environment emerge when it comes to elaborating on these mental states and working through their implications in real life settings. It is likely that the social cognitive understanding of children with ASD would benefit from exposure to explicit explanations and elaborations of cognition and affect terms, as is the case for TD children, in parent interaction as well as language intervention.

Categories of maternal speech.

Using a distinct coding system to the one discussed above on responsive utterances, Venuti et al. (2012) examined the functions of maternal utterances to Italian children with Downs syndrome (DS), ASD or TD of a similar developmental level (*M* age approximately 25 months). Maternal speech during free play sessions was classified into four categories: "information-salient," that is propositional utterances that served to exchange information, "affect-salient," which included emphatic and playful utterances, "child name," involving use of the child's name or nickname to gain attention, and "other maternal speech." Global similarities were found among mothers in the 3 groups, for instance in the total amount of maternal speech, information-salient speech, other maternal speech, and the number of information-salient descriptions. Nevertheless differences in interaction style were reflected in some significant differences between groups. Mothers of both developmentally disabled groups asked fewer questions and made fewer references to the environment, but used more direct statements and references to their children's actions compared to mothers of TD children. A couple diagnosis-specific effects emerged: Mothers of children with ASD called their name more often than did mothers of TD children, and mothers of children with DS used more affect-salient speech than

TD children.

This study replicates the finding of similarities in overall quantity of utterances directed by parents to their children with ASD or TD in another language, Italian, and importantly adds an additional control group with Downs Syndrome. Questions posed to children once again surfaced as a source of group differences, as reported for both parent-child interaction and book reading contexts; importantly however this study showed that questions were reduced in parental input to children with either disability and was not specific to ASD. Confirming the need to scaffold interaction with children with ASD, parents made more attentional bids (calling name) to children with ASD than other groups.

Discussion

In this chapter we examined the *nurture* side of language development in ASD, that is, the language environment available to children by virtue of quantitative and qualitative aspects of their parents' linguistic and interactive behaviors surrounding language use. When children are matched on language ability, and thus the *nature* side of the puzzle is controlled for this factor, comparisons of parental input to children with ASD relative to children without ASD reveal many global similarities with a few emerging areas of difference. We found no evidence of group differences in parental input obtained during naturalistic free play with respect to *lexical features* (i.e., word tokens, word types, and lexical diversity), *word-specific features* (word frequency, contextual diversity), or *syntactic complexity* (MLU). The provision of similar linguistic environments to children with and without ASD has been demonstrated in French (Bang & Nadig, 2015) and Italian (Venuti et al., 2012), as well as English. Another domain of parental input that has been extensively examined is that of *parental responsiveness,* or the provision of verbal or gestural input contingent on the object or event currently holding the

child's attention, as well as responsive utterances used for specific functions. The findings here largely echo those seen in areas of lexical and grammatical input: parents of children with ASD are as responsive to their children's attention and comprehension needs as parents of children without ASD of the same language level. Given this evidence we can rule out the possibility that the language delay observed in many but not all children with ASD stems from wholesale differences in *nurture* or the composition of the language input they receive.

Critically, however, children with ASD are receiving this similar input, commensurate to their language level, at a later point in maturation. This is due to the linguistic environment being inherently dyadic (i.e., the more a child initiates, the more opportunities an adult has to respond), combined with the fact that children with ASD are less socially interactive by definition (American Psychiatric Association, 2013), a *nature*-related factor. Consequently when children with ASD (specifically, those who exhibit language delays) and TD children are compared at the same point in maturation, both child and parent or *nurture* sides of the interaction show reductions in, for example, child vocalizations, parent-child conversational turns, and reciprocal feed-back loops (Warren et al., 2010, Warlaumont et al., 2014).

Having established that children with ASD have access to a rich language-learning environment, a critical next step is to examine whether they are able to use the data available to foster language development. The answer to this question is a resounding yes: *varied and complex lexical and syntactic input* is significantly associated with better language 6 months (Bang & Nadig, 2015) and even up to 18 months later (Goodwin et al., 2015). Additionally, more *responsive* parental utterances and gestures are followed by positive language outcomes at 6 months (McDuffie & Yoder, 2010), 1 year (Haebig et al., 2013b; Siller & Sigman, 2002), 3- to 4-years (Haebig et al., 2013a; Siller & Sigman, 2008), and even up to 10 and 16 years later

(Siller & Sigman, 2002). One type of responsive utterance, *follow-in comments,* has been shown to specifically benefit children with minimal language abilities (i.e., fewer than 10 words; Haebig et al., 2013a, 2013b; McDuffie & Yoder, 2010). These findings demonstrate that, though less studied than *nature*-related factors, *nurture*-related factors play a significant role in predicting language development and explaining variability among children with ASD, as they do for TD children. Further research is needed to explain how, or which, children with ASD are able to benefit from language input in these ways despite reductions in preferential attention to child-directed speech observed in subgroups of children with ASD (Kuhl et al., 2005).

Diverging from the many similarities noted above for more basic quantitative and qualitative measures of parental input to children with ASD, an area of difference that has been observed is a *reduced number of certain types of questions* in free play settings (Goodwin, Fein, & Naigles, 2015, Venuti et al., 2012, but see Swensen, 2007, Wolchik, 1982, Wolchik, 1983 for non-significant differences), as well as during shared storybook reading (Smith & Nadig, 2012, Gonzalez- Barrero & Nadig, 2013). Children's language and social impairments appear to constrain the questions their parents pose to them, despite the fact that children with ASD in these studies were as linguistically able to respond to the questions as TD children. It seems the domain of questions may be especially sensitive to differences that emerge through the course of dyadic *nature-nurture* interaction, which may lead parents to have different communicative expectations of their children. Importantly, the same reduction in questions posed by parents was found for children with Downs Syndrome (Venuti et al., 2012), indicating that this is likely not an ASD-specific phenomenon. Future work is needed to understand causes and consequences of reduced questioning during interaction, as questions are a particularly rich source of linguistic information because they highlight words, auxiliaries, and constituent structure and serve the

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pragmatic functions of turn-taking and learning about others' points of view. The benefits of incorporating dialogic reading strategies, which emphasize questioning, should be investigated for ASD interventions, as they have been shown to improve language in other populations (e.g., Whitehurst et al, 1988). Another difference potentially linked to patterns of dyadic interaction is a *reduced elaboration and explanation of cognitive and affective terms* in speech to children with ASD relative to TD children (Slaughter, Peterson & Mackintosh, 2007). Other differences are likely to be uncovered as detailed investigations of input to children with ASD progress, it will be essential to investigate the same features in input to children with non-ASD developmental delays before concluding that any differences are ASD specific.

Related to dyadic interaction, numerous findings have showcased parents' sensitivity to the abilities of their children with ASD. For instance, language input was differentially adapted to child language (Cantwell, Baker, & Rutter, 1977; Konstantareas, Zajdeman, & Homatidis, 1988). Likewise, repeated labelling of novel objects (Bani Hani, Gonzalez-Barrero & Nadig, 2012) and increased bids for attention and utterances to hold children on task (Kasari 1988) were observed for children with ASD who had lower language relative to those with higher language abilities. These findings demonstrate that parents provide input that is calibrated to their children's abilities, arguing for the methodological practice of matching groups with respect to language rather than age when investigating parental input.

This body of work holds important implications for clinical practice, education and families with children with ASD. It shows that, like children without ASD, children with ASD make use of the language they hear and benefit from *lexically rich and syntactically complex input*. As children with ASD hear the greatest number of words during day-to-day activities and routines (Burgess, Audet, & Harjusola-Webb, 2013) caregivers should be encouraged to provide

a rich language learning environment during these interactions. Other aspects of input that have been repeatedly shown to be positively related to long-term language gains are *responsive utterances and gestures that* follow into the children's attentional focus and create situations of joint engagement. Finally, this body of findings provides strong support for parent-implemented language interventions, which have been shown to have significant positive effects on receptive and expressive language skills in ASD (McDuffie et al., this volume, Roberts & Kaiser, 2011).

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Table 1. Top 10 Most Frequent Words Spoken by Mothers to Children with ASD and TD Children

English-speaking		French-speaking	
ASD (n = 11)	TYP (n = 11)	ASD (n = 9)	TYP (n = 9)
you	**you**	**tu**	**tu**
it	**it**	**aller**	**ça**
go	**go**	**ça**	**aller**
what	**baby**	**faire**	**avoir**
that	**I**	**avoir**	**faire**
I	this	**je**	**lui/elle**
baby	**what**	**pas**	**je**
there	child's name	regarder	**pas**
her	**that**	**lui/elle**	mettre
put	not	bébé	petit

Table 1 depicts the top 10 most frequent words spoken by mothers to children with ASD and TD children in English-speaking and French-speaking families. Words in bold are shared between diagnostic groups within the respective language.

Figure Captions

Figure 1 depicts the contextual diversity for individual words spoken in our corpora by mothers of children with ASD and TD children in English (above) and French (below). Following Hills et al. (2010), this was calculated within a window of 5 words before and 5 words after the target word and analyses included words that 1) parents used during the parent-child interaction and 2) appear on the Mac-Arthur Bates Communicative Developmental Inventories (MCDI; Fenson et al. 2007). For presentation purposes, words with very high (i.e., values > 370) or low contextual diversity (i.e., values < 30) were not included. This figure demonstrates a strong positive correlation between diagnostic groups, which demonstrates that in both languages, mothers of children with ASD and mothers of TD children produced the same words in similar contexts.

Author's note, not to be printed: Figure 2 was previously published in Autism Research, Wiley Online Publishing (Bang & Nadig, 2015). We have obtained permission to reprint but are not allowed to modify the caption as it appeared in the article, thus we have not explained acronyms and cannot change the acronym TYP to TD for typically-developing group to match the rest of the manuscript.

Figure 2 depicts the raw data observed for each dyad: maternal input MLU and the respective child's T3 % of words spoken on the MCDI. Regression lines depict the simple slopes for each diagnostic group calculated from the final regression model (Step 4), which holds all other predictors at their mean value. This figure demonstrates a positive linear relationship between input MLU and children's T3 productive vocabulary, which did not differ significantly between ASD and TYP groups.
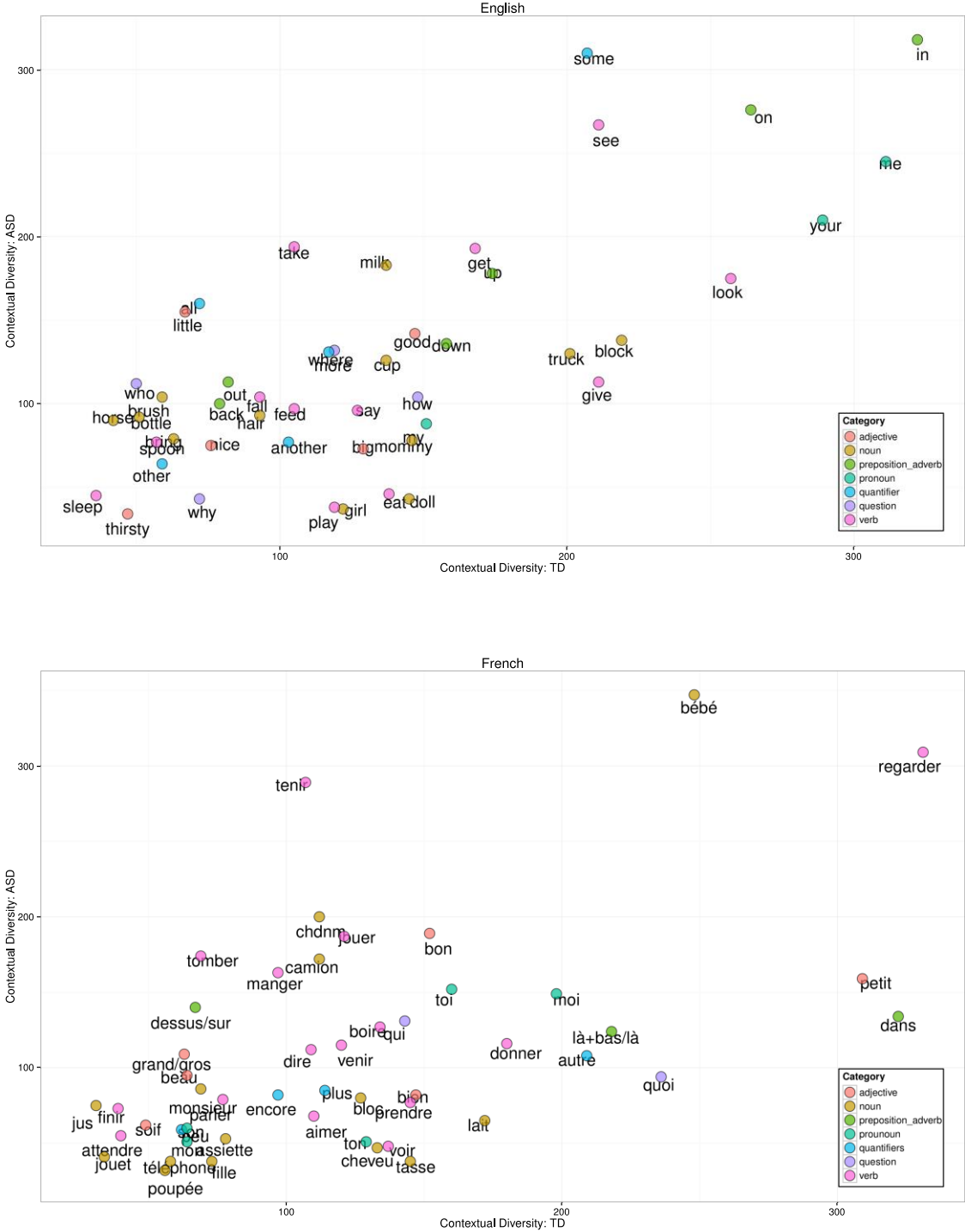
Figure 1. Contextual Diversity of Maternal Input

Figure 2. Maternal Input MLU and Later Child Vocabulary