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Joint Attention, Supported Joint Engagement and Follow-In Comments in the Language Acquisition Process of Typically Developing Children and Children with Autism: A Longitudinal Analysis

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This study compared between the roles of the socio-pragmatic and data-driven aspects of caregiver input in the vocabulary development of both Typically Developing (TD) Children and children with Autism Spectrum Disorders (ASD). The role of Joint Attention (JA) and Supported Joint Engagement (SJE) episode types, as well as Follow-In (FI) Comments, in the vocabulary development of TD Children and children with ASD, was investigated. The children with ASD consisted of two groups: High-Verbal (HV) and Low-Verbal (LV) children with ASD, in order to assess the effects of the different aspects of caregiver input on different initial language levels. Overall, Initiating Joint Attention (IJA), Responding to Joint Attention (RJA), Joint Attention that is Mutually established (MJA), as well as the FI utterances that were produced during these three episode types during the first three visits, significantly predicted later receptive and expressive language scores at visit 6, while utterances produced during PA, as well as utterances that were not FIs, negatively predicted later receptive and expressive language scores at visit 6. SJE measures did not predict later vocabulary scores, as shown in previous literature. The findings suggest that in these groups of children, the socio-pragmatic aspects played a larger role with LV children with ASD, whereas it played a milder role with both HV children with ASD, as well as with the TD children.

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Chapter 1: Introduction/Background

It is beyond dispute that in order for children to be able to acquire a language, they need to be at least exposed to it in some form of interaction (for an overview, see Mayberry & Eichen, 1991; Moerk, 1994; Skuse, 1988). Word learning is the process in language acquisition where children identify novel words and map meanings onto these novel words (Baldwin, 1991). Interactions between children and their caregivers are an important source of *linguistic input* in order for children to learn new vocabulary, but there is an ongoing debate as to what aspects of the linguistic input produced by the caregiver in particular have such effects.

Based on the hybrid view of word learning (Hollich, Hirsh-Pasek, Golinkoff, Brand, Brown, Chung, & Rocroi, 2000), generally speaking, a successful word learning task should have three important components, as Hoff and Naigles (2002) show: First, it needs a successful segmentation of the words. Secondly, an initial fast mapping of the novel word is performed onto a referent (where the child maps the new word with the target object, whether that referent is an object, action, or event). Finally, the child completes the lexical entry and is able to generalize the use of the novel word in different contexts. There is an ongoing debate as to how infants fast map the novel word onto the correct referent. It has been suggested that there are two aspects of conversation that help children learn new words, due to their relevance with regards to the role of input in Typically Developing (TD) children, as well as in children with Autism Spectrum Disorders (ASD)

On the one hand, the data-driven view investigates the *structural* properties of maternal speech (Hoff- Ginsberg, 1986), where there are certain structural properties of the utterances themselves (for example the position of the word in the sentence, intonation, word types, word tokens, lexical richness, Mean Length of Utterance (MLU), and so on) that provide the information needed by children in order to figure out word meaning. Therefore, the children can learn novel words whether the words are directed at them or not, since the learning of the new words is not based on whether the child is in an

interaction or not (e.g. in computer simulations, see Siskind, 1996). An example of studies that support this view include studies on word segmentation. Word segmentation is one of the main criteria for successful word learning. Aslin, Saffran, and Newport (1999), Gomez and Gerken (1999) and Saffran and Wilson (2003) have shown that infants under one year of age are able to use transitional probabilities of adjacent syllables to locate word boundaries, as well as subsequently discover the possible orderings of the words. This constitutes the beginning of the child's ability to use structural properties from the caregiver's input in order to both learn new words, as well as learn basic word combinations that constitute the syntax of the language learned (e.g. when the child learns and produces the sentence: "Push truck", and the child acquires the word order of this sentence, where the verb "push" precedes the object "truck", and uses it in other contexts, such as "play car"). Other examples of studies that support the data-driven view include Huttenlocher, Haight, Bryk, Seltzer, and Al (1991), Huttenlocher, Vasilyeva, Cymerman, and Levine (2002), Naigles and Hoff-Ginsberg (1998), among others.

Hoff and Naigles (2002) observed TD children between 18 and 29 months at the start of the study, and followed them up 10 weeks later. The researchers compared the data-driven aspect measures (total number of utterances produced, the number of word tokens (i.e., the total number of words) in the input samples, the number of word types (i.e, the number of different words), and the Mean Length of Utterance (MLU)) to the socio-pragmatic aspect measures (number of maternal utterances produced during episodes of joint attention, and number of maternal utterances that were topic-continuing replies to child speech). Hoff and Naigles (2002) revealed the benefits of data provided in mother-child conversation, but did not show effects of the social aspects of those conversations. One major limitation of this study is that the measures for both aspects of word learning were not investigated in different populations, such as children with ASD, in order to investigate whether we will observe findings similar to the findings in Hoff and Naigles (2002) study in the different populations.

On the other hand, the social-pragmatic view examines the *functional* properties of maternal speech (Hoff-Ginsberg, 1986). According to this, the child is engaged in interactions that occur in a social context. In these contexts, the adult utters new words, and the child uses the information provided in these contexts to map the new words to the correct target object. Therefore, the focus is more on the context and on the caregiver providing the input in that meaningful context, rather than on properties of the words the caregiver utters. The child in these situations is being engaged in sustained attention with the caregiver concerning the target object or event, and these engagement states are defined operationally as joint attention (Bruner, 1975).

Researchers have argued that joint attention (JA; a state in which the child and caregiver alternate attention between each other and an object) plays a role in later language development (e.g. Mundy, Sigman, Ungerer, & Sherman, 1986). JA has also been found to be deficient in children with autism (e.g. Lord & MaGill-Evans, 1995). Researchers further observed an engagement state that is similar to JA, except that the child does not visually address his/her parent, and defined it operationally as Supported Joint Engagement (SJE) (e.g. Adamson, Bakeman, & Deckner, 2004). Both JA and SJE have been theorized to help in the scaffolding required for children to learn new words (Mundy et al., 1986; Adamson, Bakeman, Deckner, & Romski, 2009).

With regards to SJE, Adamson et al. (2004) and Adamson et al. (2009) demonstrated that SJE contributed to differences in receptive and expressive language outcomes, over and above the children's initial language capacity. In a later study, Bottema-Beutel, Yoder, Hochman, and Watson (2014) divided SJE into Higher order Supported Joint Engagement (HSJE; where the child reciprocates with caregiver) and Lower order Supported Joint Engagement (LSJE; where the child responds without reciprocal exchange), and found that HSJE, especially when combined with Following In (FI) utterances, contributed to later receptive (averaged z-scores across MacArthur Communicative Development Inventories scores (MCDI) words and gestures, 15 minutes examiner-child language

sample, and the behavioral portion of the Communication and Symbolic Behavior Scales – Developmental Profile (CSBS-DP); CSBS DP, Wetherby and Prizant 2002) and expressive language (averaged z-scores across MCDI words understood subscale and the raw score of the understanding portion of the CSBS-DP; CSBS DP, Wetherby and Prizant 2002), as well as social communication.

During episodes of JA and SJE, the mother produces utterances that follow into the child's current focus of attention. Such utterances are called Follow-In utterances (FI), and the words produced in such utterances (regardless of the type of engagement, which is part of the socio-pragmatic aspects of input) may be considered one example of a data-driven aspect of input. McDuffie and Yoder (2010) investigated the different types of parental verbal responsiveness that best support language learning in children with ASD, and found that two broad categories of parental verbal responsiveness predicted spoken vocabulary in children with ASD, namely Follow-In Comments (FIC), and Follow-In Directives (FID). Later, Haebig, McDuffie, and Weismer (2013) divided the Follow-In Directives (FID) even further into: Follow-In Directives for Language (FIDL, where the child is expected to provide a communicative response, e.g. "What color is that?"), and Follow-In Directives for Behavior (FIDB, where the child is expected to provide a behavioral response, e.g. "Push the button". Using the Preschool Language Scales, 4th edition (PLS-4; Zimmerman, Steiner, & Pond, 2002) to assess language abilities, and using hierarchical regression analysis, Haebig et al. (2013) found that on measuring the gains in the children's language scores 3 years later, FIDL accounted for unique variance in predicting child receptive language gains, whereas FIC produced varied effects, depending on the child's initial language levels. For minimally verbal children at 2.5 years of age, caregivers who provided more FIC utterances, had children with better language outcomes three years later. This relationship was not found with verbally fluent children.

In both of the studies aforementioned, the extent in which the engagement state during the caregiver's provision of the FI utterances (i.e. whether the FI utterances occurred in an SJE episode or

not) affected the relation between the FI utterances and later language gains was unknown. As mentioned earlier, Bottema-Beutel et al. (2014) demonstrated that HSJE combined with FI utterances contributed to later receptive (averaged z-scores across MCDI words and gestures, 15-min. examiner-child language sample, and the behavioral portion of the CSBS-DP (CSBS DP; Wetherby and Prizant 2002)) and expressive language (averaged z-scores across MCDI words understood subscale and the raw score of the understanding portion of the CSBS-DP (CSBS DP; Wetherby and Prizant 2002)), as well as social communication, but Bottema-Beutel et al. (2014) did not examine the different types of FI utterances mentioned by Haebig et al. (2013).

Based on what I mentioned above, there are several gaps in the literature that is still yet to be known. First, All of what was previously mentioned make sense, but they are all overlapping. Second, None of the researchers saw the combined and independent influences of all 3 kinds of information (JA, SJE, and FI utterances) in the same study. e.g. free and structured play, TD children and children with ASD, JA and SJE and FI. Third, When looking at the predictive value of all 3 kinds of information, it wasn't always the case that the researchers partialled out early language. Early language predicts later language.

The plan for this dissertation is to analyze in more detail how JA and SJE play a role in receptive and expressive language in both Typical Children, as well as children with ASD, to see the extent in which JA and SJE play similar roles among both groups of children. Additionally, I will perform a more detailed analysis of the different types of FI utterances and how each type contributes to later vocabulary development. By conducting these analyses, I will be contributing to the literature by looking at an additional aspect of FI utterances (where they are divided into their different types), as well as the relation between these different types of FI utterances and the different JA and SJE states and interactions.

A.1.Supported joint engagement: Definition, history, and background

Supported Joint Engagement (SJE) is an engagement state in which the child and caregiver are engaged with the same object, but the child does not give explicit attention to the caregiver through visual referencing (Adamson et al., 2004). According to most accounts, the development of coordinated joint attention spans much of infancy (Bakeman & Adamson, 1984). Before 6 months of age, infants engage only in dyadic interactions with their caregivers. Starting from 6 months of age, infants start turning away from the face-to-face interactions and move towards object exploration. In this stage, infants still seem to focus on only one aspect of their surroundings (Trevarthan & Hubley, 1978), where they focus mainly on objects, while providing few indications of their desire to share their new interest with their caregivers. Gradually, infants engage in triadic interactions by beginning to switch their gaze back and forth between the caregiver and the object.

According to Bakeman and Adamson (1984), Bruner (1983), Trevarthan and Hubley (1978) and Vygotsky (1978), caregivers provide a necessary *scaffold* or supportive structure for infants as adults begin to employ referential communicative actions during shared activities, for example object hide-and-seek (Ratner & Bruner, 1978). Therefore, caregivers free their infants of the need, at least initially, to shift their attention back and forth between the caregiver and the shared object of interest. Bakeman and Adamson (1984) looked at this particular type of engagement state, and named it *passive* or *supported joint engagement*, in comparison to the Coordinated Joint Engagement (CJE) state mentioned earlier. The passive joint engagement state is considered a transitional phase that occurs between the dyadic and triadic interactions denoted by Trevarthan and Hubley (1978) earlier.

A.2.Developmental progress of supported joint engagement

Starting from 6 months of age, children develop JA abilities, where the children learn to jointly attend to both the adult and a referent (Bakeman & Adamson, 1984; Trevarthen & Hubley, 1978) until they are able to fully enter into sustained episodes of CJE by the age of 13 months. An example of CJE

involves the following episode: a parent and child take turns putting blocks on top of each other in order to build a tower. After each turn, the child alternates between looking at and smiling towards the parent, and looking back at the blocks, Therefore, the child maintains the interaction and affect with the parent during the play experience. SJE develops prior to the CJE phase, where both the child and parent engage with the same object to the extent that the parent influences the child's object play, but the child does not explicitly address the adult via visual reference (Adamson et al., 2004).

A.3.Supported joint engagement and its relationship to later language development

While several studies have investigated SJE and its development in children (such as those mentioned in the previous sections), later studies investigated the relation between SJE and later language development. Adamson et al. (2004) coined the term symbol-infused Joint Engagement (JE), where symbols in the form of words or gestures are produced coincidentally with the JE episodes (whether coordinated or supported), leading to a major transformation in the scope of shared attention between the child and the caregiver, such that the child and the caregiver communicate about events beyond the here and now. There is mounting evidence that shows how the caregiver's speech may extend to the infant's attention to objects (Baldwin, 1995), and how during this developmental phase, words become a focus during episodes of joint attention (Tomasello, 1988). However, the relations among symbol-infusion, JE, and later language development were not addressed. Adamson et al. (2004) observed 56 TD children longitudinally from 18 to 30 months of age in child-mother interactions. The children were divided into three groups at the onset of the study, based on their initial MCDI (MCDI; Fenson et al., 1993) and Mullen receptive and expressive language scales (Mullen, 1995), and their language outcome was measured using The Peabody Picture Vocabulary Test-III (PPVT-III; Dunn & Dunn, 1997) to measure receptive language skill, and the Expressive Vocabulary Test (EVT; Williams, 1997) to measure expressive language skill. Adamson et al. (2004) found that both the timing and the trajectory of joint engagement varied widely among the toddlers, and that

symbols produced by the caregivers increasingly infused the SJE episodes. Using hierarchic regression analysis, Adamson et al. (2004) also found that the variations in the amount of symbol-infused (by the caregivers) SJE may both be influenced by variations in the initial language levels of the toddlers. After taking the initial language levels of the toddlers into account, the more caregivers infuse symbols into the interactions with their children, the higher the children's PPVT and EVT scores at 30 months of age.

In short, these findings demonstrate that SJE plays a role in later vocabulary development. However, as I will point out in the later sections, Adamson et al. (2004) only observed TD children in a suite of rooms that were designed for observational research, rather than in a naturalistic setting, such as the children and their caregiver's homes. In the later sections, I will present studies that looked at how SJE plays a role in children with autism, and discuss findings in studies observing both TD children and children with autism.

B.Autism

B.1.What is Autism?

Autism is a neurodevelopmental disorder that is characterized by difficulties in social interaction and repetitive behaviors and interests (American Psychiatric Association [APA] 2013). The degree to which children with autism engage in joint attention with other people is generally diminished and well below their chronological age level (Charman, 1998; Mundy, 2009; Mundy, Sigman, & Kasari, 1994; Naigles, 2013). Empirical evidence suggests that such impairment in autism affects their language skills (e.g. Carpenter, Nagell, & Tomasello, 1998; Morales et al., 2000; Mundy & Gomes, 1998; Stone & Yoder, 2001). In comparison to TD children, as well as children with cognitive delays who are not diagnosed with autism, Baron-Cohen, Baldwin, and Crowson (1997) and Preissler and Carey (2005) have conducted studies showing that children with autism use their own focus of attention, rather than the speaker's focus of attention, resulting in the children producing more incorrect

mappings between novel labels and objects. Adamson et al. (2004) have also shown that when parents consistently follow into their child's focus of attention, they may decrease the cognitive and affective demands on the child that are necessary for coordinating attention to both the speakers and the objects; FIs occur with fewer mapping errors.

B.2.Language Development in Autism

Researchers have explored language functioning in autism, and found that language deficits are variable across the spectrum. For example, with regards to semantic development, some studies showed impairments in semantic abilities, such as the lack of a Shape Bias (SB) in word learning (e.g. Fein et al., 1996; Kelley, Paul, Fein, & Naigles, 2006; Tek, Jaffery, Fein, & Naigles, 2008), whereas other studies have demonstrated intact semantic skills (e.g. Gastgeb, Strauss, & Minshew, 2006; Tager-Flusberg et al., 1990). With regards to syntax, several researchers have demonstrated that grammar is relatively intact in children with autism (e.g. Tager-Flusberg, 2004; Tek, Mesite, Fein, & Naigles, 2014; Tovar, Fein, & Naigles, 2015), whereas other researchers have shown that children with autism may process syntax differently, in comparison to TD children (e.g. Eigsti, Bennetto, & Dadlani, 2007; Kana, Keller, Cherkassky, Minshew, & Just, 2006). To summarize, even though it has been demonstrated by several researchers that children with autism have language impairments, there is little consensus among the researchers with regards to which aspects in particular are impaired. This lack of consensus is likely attributed in large part to (a) the heterogeneity of the autism presentation, and (b) possibly an over-reliance on standardized tests (Naigles and Chin, 2015; Naigles and Fein, 2017).

B.3.Autism, Supported Joint Engagement and Language Development

In typically developing children, the duration of SJE episodes that are infused with language significantly positively predicted later receptive and expressive language (Adamson et al., 2004, 2009). Adamson et al. (2009) also divided the children with autism in their study into two groups - a nonverbal and a verbal group – based on their language onset, using the MacArthur Communication

Development Inventories (MCDI; Fenson et al., 1993). Using hierarchical regression analysis, and after controlling for the initial MCDI scores, the amount of SJE the children with autism experienced accounted strongly for variability in both PPVT-III (PPVT-III; Dunn & Dunn, 1997) and EVT (EVT; Williams, 1997) scores. The authors have also demonstrated that with respect to the amount of time spent in SJE, there was no difference between 30-month old children with autism and language matched 18 month old TD children. However, there is frequently delayed or absent speech in children with autism (Bottema-Beutel et al., 2014). One possible explanation for this delay is that the language learning context of children with autism might be different from that of TD children (Sigman et al., 1999; Tager-Flusberg, Paul, & Lord, 2005). TD children are generally aware of and engaged with the caregiver whenever the caregiver influences the child's play with toys (Adamson et al., 2004), whereas children with autism are more likely unaware of or even reject the caregiver's bids for interaction during toy play (Adamson, McArthur, Markov, Dunbar, & Bakeman, 2001). Therefore, in order to explicitly measure these behavioral differences and incorporate these measurements in the SJE framework, Bottema-Beutel et al. (2014) divided the SJE state into two categories. In Higher order Supported Joint Engagement (HSJE), the child clearly demonstrates engagement with the caregiver via reciprocal play with toys and objects (e.g. caregiver and child take turns putting blocks on top of each other to build a tower), whereas in Lower order Supported Joint Engagement (LSJE), the child responds to the caregiver, but does not demonstrate such reciprocity (e.g. child moves the block, but does not engage with the caregiver to build a tower). Using separate multiple linear regressions, Bottema-Beutel et al. (2014) demonstrated that only HSJE predicted later expressive language (using an expressive language aggregate that consisted of the MacArthur Communication Development Inventories (MCDI; Fenson et al., 1993) words and gestures subscale, as well as the Communication and Symbolic Behavior Scales Developmental Profile (CSBS DP; Wetherby & Prizant, 2002)) and social communication (via summing up the raw totals from the Social Interaction and Joint Attention

portions of the CSBS DP; Wetherby & Prizant, 2002), and when infused with symbols (FI utterances in this case), HSJE+FI predicted receptive (using a receptive language aggregate that consists of the MCDI understood subscale, as well as the raw scale of the understanding portion of the CSBS and expressive language, as well as social communication.

To summarize, SJE significantly predicts later language development in children with autism, and the findings demonstrated by Bottema-Beutel et al. (2014) support the suggestion of redefining SJE into HSJE and LSJE, in order to better demonstrate the effects each SJE state has on later language development.

There are similar gaps with regards to the literature on SJE that have not been addressed. The researchers did not always examine the combined and independent influences of all kinds of information in the same study (e.g. free and structured play, TD children and children with ASD, JA and SJE and FI), in order to see if there were any significant differences between the two groups, and how such differences impact later language development, if any. In this section, I will explain in more detail the limitations of the previous literature. Bakeman and Adamson (1984), Adamson et al. (2004) and Adamson, Bakeman, Deckner, and Nelson (2014) explored SJE in TD children, whereas Bottema-Beutel et al. (2014) explored SJE in children with ASD. Adamson et al. (2009) compared the SJE framework (without the HSJE and LSJE distinction) in TD children, children with ASD and children with Down's syndrome. Adamson et al. (2004) and Adamson et al. (2009) coded the interactions between the children and their caregivers using the Communication Play Protocol (Adamson & Bakeman, 1998, 1999), and this protocol uses a series of semistructured conditions, where the caregivers are asked to perform a Communication Play with their children. Each Communication Play facilitates the caregivers' and their children's engagement in the four communicative contexts of interacting, requesting, commenting and narrating, and the Communication Plays are performed in a series of scenes, two scenes for each context, with a total of eight 5-min scenes. However, in order to

switch into a new scene, the play's director knocks on the playroom door and enters to provide the caregiver with the cue card for the next play scene. The cue card contains suggestions for how to perform the new scene, rather than clear instructions on what to do exactly in the new scene. This leads to brief periods of interruption of the interaction between the caregivers and their children, and therefore there could be some form of engagement during the interruptions that might be missed. In the study conducted by Bottema-Beutel et al. (2014), the authors conducted the study using the Parent-Child Free Play Procedure (PCFP), where the caregiver and the child are asked to play with a set of toys the way they normally play at home. No other instructions are given, and the play session is recorded for 15-min. Therefore, Bottema-Beutel et al. (2014) investigated caregiver-child interactions in free play only. This means that because there are two different methodologies used in the different studies, one cannot generalize the findings of the different studies. In free play, the interaction between caregivers and their children are more naturalistic, and there are more chances for the children to initiate JA and SJE episodes, while in structured play, the caregivers have to follow instructions given to them by the investigators, therefore the caregivers are the ones initiating more JA and SJE episodes with their children. Therefore, we need to observe the interactions between the caregivers and their children in both free play and structured play, in order to capture as much episode types as possible in different contexts.

This study aims to close the gaps mentioned above in the previous literature by using a methodology that codes the parent-child interactions in both types of play (free and structured), as I will fully explain later in the Parent-Child Interactions subsection in the tests and measures section. Bottema-Beutel et al. (2014) used three separate multiple linear regressions to measure the effects of both SJE and FI comments on later language development, rather than hierarchical linear regressions used by most of the authors who examined SJE and FI comments, such as Adamson et al. (2004) and Haebig et al. (2013). This means that even though Bottema-Beutel et al. (2014) showed that SJE and FI

comments each predict later vocabulary development, it is not actually known how much unique variance does SJE and FI utterances contribute separately to later vocabulary development, and therefore the relative importance of SJE and FI comments separately, in relation to receptive and expressive language scores, cannot be determined. Bottema-Beutel et al. (2014) also did not contrast their findings with other engagement types, such as the different types of JA. Since SJE and JA are different, because of the lack of the visual component in SJE, SJE and JA need to be compared with each other, in order to investigate the extent in which the decrease the cognitive load on the child (by not visually addressing his/her caregiver) helps scaffold their word learning, compared to fully addressing the caregiver in JA.

Therefore, I will examine the number and duration of HSJE and LSJE episodes, and contrast these numbers with the number and duration of the different types of JA episodes, in both TD children and children with autism. The number and duration of JA and SJE episodes are considered part of the social-pragmatic aspects of input that help children learn new words.

C.Follow-in utterances

During episodes of JA and SJE, the mother produces utterances that follow into the child's current focus of attention. A separate line of research has examined how synchrony - or caregiver verbal responsiveness - of the cargiver's verbal input with the child's current focus of attention plays a role in later language development of the child. Researchers have found that such synchrony helps predict later vocabulary development, as well as rate of language growth. When the caregiver's utterances are produced around the child's focus of interest, the child does not need to shift attention to a new object, therefore decreasing the cognitive and affective demands required by the child to jointly attend to both people and objects (Adamson et al., 2004), and increasing the possibility that the child will attend to the utterance. This type of synchrony has been termed FI, and has been researched from as early as 1983 (e.g. see Tomasello & Todd, 1983). Carpenter et al. (1998), Harris, Jones, Brookes,

and Grant (1986) and Tamis-LeMonda, Bornstein, and Baumwell (2001) demonstrated how synchrony of the caregiver's input with the child's current focus of attention predicted later expressive and receptive language in Typically Developing children, whereas McDuffie and Yoder (2010) showed how synchrony of the caregiver's input with the child's current focus of attention predicted later expressive and receptive language (using the MCDI and stepwise regression analysis) in children with ASD. Yoder, Watson and Lambert (2015) identified FI utterances as value-added predictors that are associated with later expressive vocabulary, along with intentional communication, RJA and Diversity of Key Consonants used in Communication (DKCC), and McDaniel, Yoder and Watson (2017) studied FI utterances with 87 preverbal children with ASD, and demonstrated that FI utterances accounted for unique variance in expressive vocabulary 16 months later when controlling for mid-point receptive vocabulary.

McDuffie and Yoder (2010) investigated the different types of parental verbal responsiveness that best support language learning in children with ASD, and found that two broad categories of parental verbal responsiveness predict spoken vocabulary in children with ASD, namely FI Comments (FIC), and FI Directives (FID). Even though such findings looked at how the different types of follow-in utterances contribute to later language abilities in both TD children and children with ASD, such studies had four major limitations; analysis of short-term longitudinal data (e.g. 6 months in time), assessing a limited number of predictor variables, not controlling for early language at visit 1, and a limited sample size. Haebig et al. (2013) addressed these limitations by increasing her sample size (34 parent-child dyads diagnosed with ASD), conducting a larger longitudinal investigation (annual comprehensive evaluations for 4 visits), controlling for early language at visit 1, and dividing the follow-in directives (FID) even further into: Follow-In Directives for Language (FIDL, where the child is expected to provide a *communicative* response, e.g. "What color is that?"), and Follow-In Directives for Behavior (FIDB, where the child is expected to provide a *behavioral* response, e.g. "Push the

button"). Haebig et al. (2013) has found that when measuring the gains in the children's language scores 3 years later, FIDL predicted child receptive language gains, whereas FIC produced varied effects, depending on the child's initial language levels. FIC benefited the minimally verbal at age 2.5 years old, but did not benefit the verbally fluent children.

In all of the studies aforementioned, the extent in which the engagement state during the caregiver's provision of the FI utterances (i.e. whether the follow-in (FI) utterances occurred in an SJE episode or not) affects the relation between the FI utterances and later language gains was unknown. Bottema-Beutel et al. (2014) observed such a relationship in 63 preschool-age children with ASD and found that HSJE+FI predicted later receptive language, expressive language and social communication 8 months later. Even though such findings are an addition to the literature on the relationship between the different engagement states, FI and later language development, there were several limitations to this study. First, the study was only conducted on children with ASD, and did not include TD children as a comparison group, in order to see if the findings are universal among all populations, or do they vary based on the group; i.e. will there be group effects, especially based on language levels at visit 1 (therefore, are all ASD children going to produce the same effects, or will I find different effects with the High Verbal children with ASD, compared with the Low Verbal ASD, and both in comparison to TD children). Second, comparison of the effect of SJE and FI utterances with the effect of JA and FI utterances was not performed in the same study.

Dissertation

Based on the limitations of the previous studies in the literature, in this dissertation, I will further investigate the number and types of FI utterances, which are considered part of the second aspect of input that help children learn new words; the data-driven aspects of input. Since I am researching JA and SJE, I will also investigate the Follow in utterances the mothers produce during the

different JA and SJE episode types. This will allow me to make direct comparison of both aspects within the same JA/SJE episodes.

In this dissertation, I conducted two different types of analyses: I performed detailed analyses of spontaneous speech samples from parent-child play sessions, with focus on the parents' FI utterances, and I compared the children with ASD to their language-matched typical counterparts. Moreover, in the area of joint attention in autism, previous research has primarily employed the Early Social Communication Scales (ESCS; Mundy, Hogan, & Doehring, 1996; Seibert, Hogan, & Mundy, 1982), which measures the presence of JA in an experimental setting. In contrast, in my second analysis, I coded and analyzed the JA and SJE behaviors in both TD and ASD children from 30-minute parent-child interactions in a naturalistic setting. The TD children are included as a control group, since several studies that looked into SJE have not used any control group (e.g. Bottema-Beutel et al., 2014). The spontaneous speech measures and the joint attention measures were used to predict later expressive and receptive language measures. The expressive measures included nouns types and tokens, verbs types and tokens, MLU and Mullen Expressive Language at visit 6, while the receptive language measures included Shape Bias at visit 4, and Mullen Receptive Language at visit 6. The Shape Bias (SB) is a mechanism that facilitates rapid word learning in young children (Tek et al., 2008). When children use the shape bias, they selectively attend to shape to extend a newly-learned word to a new object (Smith, 2000). For example, the child is presented with a new object (e.g. this is a dax), and then the child is asked (Where is the dax?), in which the child looks at the newly introduced test object that is similar to the exemplar in shape. The justification for using the SB is due to research showing that the usual measures of early language may not be stable in children with ASD, and therefore the standardized measures commonly used may not be reflecting accurately the children's varying levels of linguistic knowledge (Naigles and Fein, 2017).

To my knowledge, this study is the first longitudinal study that included such an extensive comparison of JA and SJE episode types and later language skills between young typical children and children with ASD, using the methodology suggested above.

Hypotheses

Concurrent with previous research, I hypothesize that in relation to Hoff and Naigles (2002) findings, I will find that the social-pragmatic aspects of maternal input will play a larger role in predicting later vocabulary development in children with ASD, compared to TD children. I also hypothesize that when I divide the children with ASD into High Verbal (HV) and Low Verbal (LV) groups, I will also find differences in their findings. I also hypothesize that I will find significant differences between children with ASD and TD children in the amount of time they spend with their caregivers in the different types of both JA and SJE episodes, therefore comparing the extent in which the amount of time spent in the different JA and SJE episodes contributes to later language levels. In addition, I also hypothesize that I will find significant differences between children with ASD and TD children in the amount and type of FI utterances they receive from their caregivers in the different episode types, and that the degree in which FI utterances plays a role in later vocabulary development depends on the type of episode in which the FI utterances are produced.

Chapter 2: Methods

Participants

Thirty-three typically developing (TD) children and thirty-one children with ASD participated in this study. Their data were collected across three visits, each of which was separated by four months. The ASD group was recruited through treatment facilities and schools in Connecticut, Massachusetts, Rhode Island, New York, and New Jersey; the children ranged in age from 18 to 42 months (M = 32.9, SD = 3.5) at the beginning of the study, and they were matched on their language scores in Visit 1 (see Table 1). In the ASD group, there were four girls and twenty-seven boys, and they had been diagnosed with Autism Spectrum Disorder by professionals prior to the beginning of the study. Their diagnosis was confirmed with the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, Goode, Heemsbergen, Jordan, Mawhood & Schopler, 1989) and Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Renner, 1988) before the start of the study. According to ADOS scores, twenty-one children were qualified for a diagnosis of Autistic Disorder (ADOS score > 12; see Table 1), and the other ten children were on the ASD spectrum. The TD group included four girls and twenty-nine boys, ranging in age from 18 to 23 months (M = 26.6, SD = 4.5) at the beginning of the study; they were recruited from a database of children at the University of Connecticut Child Language Lab. The study was IRB approved, and written consent was obtained from the caregivers. The children's scores on standardized tests at Visit 1 are summarized in Table 1.

Tests and Measures

A. Standardized Test Measures

A.1. The Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, Goode, Heemsbergen, Jordan, Mawhood & Schopler, 1989) is a structured play and interview session for the diagnosis of Autism Spectrum Disorders. It consists of a series of activities designed to interest young children and encourage them to communicate. It also provides opportunities to observe social interactions including

affect sharing and social referencing, as well as symbolic play. The ADOS was administered at visits 1 and 5.

A.2. The Childhood Autism Rating Scale (CARS; Schopler et al., 1988) is another tool that is used for both distinguishing children with autism from developmentally handicapped children who are not autistic, as well as for determining the level of severity in children with ASD. The CARS consists of 15 subscales; the clinician observes how the child responds to structured activities, and rates the child accordingly. The CARS was administered at visits 1 and 6.

A.3. MacArthur Communicative Development Inventory (MCDI; Fenson, Dale, Reznick, Thal, Bates, Hartung, Pethick & Reilly, 1993). The MCDI is a standardized parent reporting instrument used to assess the early language development of children. The infant version of the MCDI was used, which is the version for TD children aged 8 to 16 months. The infant version is composed of two major parts, which together include 396 words. Part I contains a series of questions followed by a comprehensive vocabulary checklist, including nouns, verbs, adjectives, pronouns, prepositions, and quantifiers. Part II focuses on the child's use of actions and gestures in order to provide a more comprehensive evaluation of early communication skills. The infant version was given to all children at visit 1.

A.4. The Vineland Adaptive Behavior Scales, Second Edition (Sparrow, Cicchetti, & Balla, 2005) is a parent report interview that evaluates children's adaptive functioning across the domains of communication, daily living skills, socialization, and motor skills. The Vineland Adaptive Behavior Scales has been widely used by professionals as a measure of personal and social skills needed for everyday living to identify individuals who have developmental delays, Autism Spectrum Disorders, or other impairments. The Vineland Adaptive Behavior Scales was administered at visits 1 through 6.

A.5. Mullen Scales of Early Learning (Mullen, 1995). The Mullen Scale is a measure of intellectual development, which includes items that measure visual reception, expressive and receptive language, and motor development for children from birth to 5 years, 8 months. The Mullen provides

both standard T scores and age equivalent scores for each domain of the test. The Mullen Scale was administered at visit 1 and 6.

Procedure

At visit 1, children were visited in their homes, and were administered the standardized measures, which included the ADOS, CARS, Mullen, and Vineland. The MCDI had been mailed to parents ahead of time, and was collected at the end of the session. At visit 1 through visit 3, prior to the beginning of the parent-child play session, children were also administered some experimental tasks, which are not part of this study.

Joint attention/engagement and passive attention measures were coded from the 30-minute semi-structured parent-child play sessions that were carried out in the participants' homes. The first five minutes and last ten minutes (15 minutes total) of the parent-child play sessions involved free play, in which the caregivers were instructed to play with their children as they normally would. The middle 15 minutes followed the structure of the Screening Tool for Autism in Two-year-olds (STAT, Stone et al., 1994). The STAT consists of 12 play-based activities that involve the child in pretend play with dolls, interactive play with a ball or truck, imitative action play, and requests and joint attention (e.g., pointing, reaching, etc.). To ensure that the caregivers followed this structure, the experimenter handed cards to caregivers which stated what the caregivers should be doing with their children.

B. Joint Attention/Engagement and Passive Attention Measures

Joing Attention and Passive Attention Coding

The coding scheme for RJA and IJA (see Table 2) was adapted from Roos, McDuffie, Weismer, & Gernsbacher (2008), which was based on the Early Social Communication Scales (ESCS, Mundy et al., 2006). However, unlike the ESCS, which was developed to measure Joint Attention in an experimental setting, Roos et al.'s (2008) coding scheme was developed to measure Joint Attention in a more naturalistic environment. During the play sessions, the RJA behaviors included children's

turning or gaze switching as a response to parents' verbal directives, which were intended to shift the child's attention to the object that the parent was attending to. Unlike the ESCS, which provides the child with clear behavioral prompts to elicit RJA (i.e., after securing the child's attention on the experimenter, using pointing or verbal prompts such as "Look (child's name)!"), in a naturalistic setting, the verbal directives of parents were less systematic and varied widely. They included calling the child's name, using imperatives (e.g., "Look!" "Put the blocks together!"), questions (e.g., "Do you wanna play with the baby?" "What is this?"), or simple comments (e.g., "This is such a nice car!"). During the play sessions, parents always combined pointing or gesturing with speech to direct the child's attention; therefore, in this study, the RJA behaviors only include children's responses to their parents' verbal directives.

The IJA coding was also based on Roos et al. (2008), and similar to the ESCS coding of IJA (see Table 2). Similar to the ESCS, IJA coding during the play sessions included the child's making eye contact with the parent while manipulating/touching an object, alternating gaze between the object and the adult, pointing to an object, and holding an object and showing it to the parent. One of the differences between the ESCS and the play sessions was that eye contact in the play sessions had to accompany both pointing and showing behaviors to make sure that the child was initiating JA to share interest with the parent rather than independently exploring the objects (Roos et al., 2008). Moreover, because many of the participants in this study were verbal children, IJA behaviors also included initiating joint attention through language (e.g., "What is this?" "I wanna play with the car.").

The coding scheme for Mutually established JA (MJA) was also based on Roos et al. (2008), and similar to the ESCS coding of RJA and IJA, MJA coding during the play sessions included the child's making eye contact with the parent while manipulating/touching an object, alternating gaze between the object and the adult, pointing to an object, and holding an object and showing it to the parent. One of the differences between the ESCS and the play sessions was that eye contact in the play

sessions had to accompany both pointing and showing behaviors to make sure that the child was Jointly Attending to share interest with the parent rather than independently exploring the objects (Roos et al., 2008). An episode was coded as MJA when both the caregiver and the child spontaneously engaged in a joint attention episode, and there was no clear distinction regarding who initiated the episode.

Unlike Roos et al.'s study, (2008) in which a trained experimenter played with the child and ensured that some responses to JA occurred, in the current study, there were instances in which parents followed the children's attention, but the children did not overtly respond (e.g., putting a toy in front of the child, putting the child's hands on the toy and helping the child manipulate the toy, or turning on a toy that moves, gives out light or sound). We coded these instances as instigators of Passive Attention (PA), because they comprised instances of interaction in which parents guided children's focus of attention irrespective of the child's reciprocation. In young TD children, these episodes have been shown to have facilitative effects on language development (Akhtar, Dunham and Dunham, 1991; Tomasello, 1995). More specifically, the PA behaviors included instances in which parents were joining their children's attentional focus when the children were not following their parents' attentional bids. For example, one instance of PA included the parent's turning on a remote car, and the child's playing with it without displaying any JA behaviors such as eye contact. PA differs from RJA in that, for PA, parents actively join their children's attention while the children do not subsequently interact with their parents by talking to them, pointing, showing, or making eye contact. For example, when a parent starts a toy which then moves and the parent uses verbal directives at the same time, and as a result, the child looks towards the toy, it is difficult to determine if the child is responding to his/her parent's attentional bids or to the movement of the toy itself if no other behavioral cue such as eye contact or language that marks JA is present. Therefore, we coded these as episodes of PA.

Joint Engagement Coding

After coding for RJA, IJA, MJA and PA, episodes that were not JA episodes were scrutinized, in order to ascertain if there were other forms of SJE that occurred during the parent-child interactions. Unlike PA, when children showed no sign of responding to parental activities, we observed some episodes in which the child appeared to engage in Supported Joint Engagement (SJE); that is, when children responded to parental activities but without the key eyegaze or verbal responses of JA. The coding scheme for High-Supported Joint Engagement (HSJE) and Low-Supported Joint Engagement (LSJE) was adapted from Bottema-Beutel et al. (2014) (see Table 3), which was based on Adamson et al.'s (2004) framework. Bottema-Beutel et al.'s (2014) coding scheme was designed to code engagement states in parent-child interactions during a Parent-Child Free Play Session.

To be considered an engagement state, the episode must last for at least three seconds, or be composed of at least three turns. In general, SJE was coded when the child and parent were actively involved with the same object or event, and the parent's involvement seems to influence the child's activity with the object, but the child does not acknowledge this involvement. To be coded as SJE, it must appear that the caregiver's involvement with the object is in somehow influencing the child's experience of the object or event. In order for SJE to be coded as HSJE, the child should be actively responding to the caregiver's action and/or presence, thereby demonstrating an awareness of the caregiver as an entity capable of performing and controlling his/her actions (see Table 3 for examples and non-examples of HSJE). This often occurs during play that involves sequences, but a sequence of interactions alone is not sufficient evidence for "HSJE". This type of engagement must last at least three seconds and can be punctuated by instances of disengagement from the caregiver and/or symbol-infusion (such as utterances). "In general, this state is characterized by the child actively initiating or reciprocally responding to the caregiver's actions" (Bottema-Beutel, Schwartz, Louick and Keefe, 2015, p. 2). It is important to remember that this is a *state* and that single and brief reciprocal

interactions that are goal-oriented are often insufficient evidence for HSJE due to their brevity. A child's active response to a caregiver's action includes shared affect.

On the other hand, in order for SJE to be coded as LSJE, the child demonstrates little to no engagement with the caregiver. This is evidenced by passive interactions and few to no reciprocal interactions with the caregiver. The child's responses to caregiver behavior may suggest that the child does not differentiate the caregiver from objects. Children and caregivers often engage in this state when the caregiver facilitates the child's play, when a child and the caregiver momentarily engage to accomplish a goal (i.e., open a container), and when the child and the caregiver engage in parallel play. This type of engagement must last at least three seconds and can be punctuated by instances of disengagement from the caregiver and/or symbol-infusion (i.e. accompanied by either language, or with visual forms of communication, such as gestures). "In general, this state is characterized by the child and caregiver engaging in the same activity with the child as a passive participant in relation to the play-partnership" (Bottema-Beutel et al., 2015, p. 5).

The author of this dissertation coded attention and engagement measures from the data recordings frame-by-frame using a software program called ELAN (http://www.lat-mpi.eu/tools/ elan/), which is a computerized program developed to code language and language-specific behaviors from video interactions. Three well-trained undergraduate students re-coded 10% of the data for reliability (n = 14 children, randomly selected across visits). In order to prevent any biases in coding and to increase reliability, the reliability coders were blind to the children's diagnosis. The Pearson *r* for correlations among measures coded for reliability ranged from .719 ($p < .01$) to .920 ($p < .01$).

In sum, 12 measures of joint attention/engagement were calculated: number of episodes of each type, and total duration of each type during the entire play sessions.

C. Child's Spontaneous Language Measures

Language Coding

Children's speech was coded for visits 1 to 6, where visit 1 measures were used as a control, and visit 6 measures were used as outcome measures. Children's spontaneous language uttered during the parent-child play sessions was coded using a computerized language program called CLAN (MacWhinney, 1995). CLAN is a computer program developed to analyze language-specific properties in a language corpus. Undergraduate students first transcribed the play sessions, which were then transferred to CLAN for analyses. The author of this dissertation then checked the transcribed data for spelling mistakes as well as morphological assignment errors that the software might have committed. Previous research demonstrated that, compared to manual analysis, CLAN analyses of various aspects of language have 94% reliability (McWhinney, 1995). CLAN were used to code the spontaneous language uttered by both the children and their caregivers.

The language measures were based on children's spontaneous speech produced during the parent-child play sessions, as follows:

C.1.Mean Length of Utterance (MLU). Mean length of utterance (MLU), which is a simple measure of the child's sentence complexity, is calculated by dividing the number of morphemes (the smallest meaningful unit in a language) by the number of utterances in a speech sample.

C.2.Nouns. This refers to the total number of noun types and noun tokens produced by the child.

C.3.Verbs. This refers to the total number of verb types and verb tokens produced by the child.

D. Language Comprehension (Intermodal Preferental Looking Paradigm "IPL") Measures

The IPL is a method that helps tap the language comprehension abilities of very young children. In this paradigm, the children sit in front of a screen, and they see two videos that present linguistic stimuli. One video contains the "match" stimulus, while the other video contains the foil stimulus. The idea behind this paradigm is that if the child understands the target word,

he/she will look longer at the video that contains the matching stimulus. Therefore, the IPL provides an early indicator of language comprehension (Naigles and Tovar, 2012). The children's eye movements are recorded by a camera, in order to code the child's fixation on the visual stimuli. This dissertation uses the IPL data from the Shape Bias (novel word learning) task.

Shape Bias (SB) Procedure

Adapted from Potrzeba et al. (2015), the SB video was shown to each participant on a projector screen that was set up in their home. The child sat approximately four feet in front of the screen; either by themselves, upon a familiar seat of choice, or with their caregiver or visiting research assistant. Participating caregivers and research assistants wore headphones playing classical music in order to mask the audio stimuli. A digital camera, focused on the child's face, was placed centrally below the screen aligned with the child and adjusted for individual height and choice of seating arrangement. The speaker projecting the auditory stimuli was located behind the projection screen and also aligned centrally with the digital camera and child. The SB measure used was the percentage difference between proportion of looking at the matching trials of all scenes, minus proportion of looking at the matching of control trials, at visit 4. SB measures at visit 6 were not used, because visit 4 is the last visit in which both TD children and children with ASD were able to score.

E. Parental Measures

Language Coding

As mentioned earlier in the coding section for the child's spontaneous speech measures (Section B), Computerized Language Analysis (CLAN) software was used to code the spontaneous language uttered by both the children and their caregivers. As for the caregivers' speech the utterances that will be specifically coded are the three types of Following-In (FI) utterances that occur in the Joint Attention/Engagement and Passive Attention episodes at visits 1 to 3.

E.1.Follow-In Utterances: The caregiver utterances were coded at visits 1 to 3 for three types of Following-In (FI): Follow-in Comments (FIC), which describe the child's focus of attention, and there is no expectation for the child to respond to the parent, e.g., "Oooo!! A balloon!!!"), Follow-in Directives for Behavior (FIDB), which are; directives towards the child's focus of attention, where the parent expects the child to respond behaviorally to their immediately preceding utterance, e.g., ''Put the car down.'' when the child holds a car), and Follow-in Directives for Communication (FIDC), which are; directives towards the child's focus of attention, where the parent expects the child to respond communicatively to their immediately preceding utterance, e.g., ''What color is that?'') (adapted from Haebig et al., 2013). The spontaneous language variables are summarized in Table 4.

Chapter 3: Results

My first research question investigates whether there are group effects on both JA/SJE episode types and FI utterances. The first analyses of this study will involve group comparisons on the attention and engagement measures, combined across all three visits. Since there is a considerable variation in the language profile of the ASD group, the ASD group will be divided into two groups; the first group consists of the High-Verbal (HV) children with ASD, and the second group consists of the Lower-Verbal (HV) children with ASD (see Table 5).

My second research question examines whether both the JA/SJE episode types and FI utterances differ within groups, therefore allowing me to make a direct comparison between the socio-pragmatic aspects and data-driven aspects in both TD and ASD groups in the same study. The second set of analyses will involve conducting ANOVAs and post hoc analyses of the amounts and percentages of the different episode and utterance types produced within groups, as well as between groups.

With regards to my third research question, I want to investigate the early social-pragmatic and data-driven measures, and their relation with the later output measures. The third set of analyses will conduct partial correlations that investigate the relationships between children's attention and engagement measures, as well as the parental language measures, at visit 1, and the children's language measures at visits 4 and 6. Based on these correlations, I look into whether the early social-pragmatic and data-driven measures predict later language development in both TD children and children with ASD. Regressions will be conducted to investigate models of which early measures predict the children's language measures at visits 4 and 6, and non-verbal IQ and expressive and receptive language scores at visit 1 were partialled out, in order to control for early language and non-verbal IQ before conducting these regressions.

1.Group effects.

Between-group comparisons were conducted on the JA and SJE time and count measures; the means and standard deviations are presented in Tables 6 and 7. TD children engaged in significantly more and longer episodes of IJA than both groups of children with ASD across all three visits. Both TD children and HV children with ASD also engaged in significantly more and longer episodes of RJA than the LV children with ASD across all three visits, whereas the TD children and HV children with ASD were not significantly different from each other. LV children with ASD engaged in significantly more and longer episodes of PA than both HV children with ASD and TD children. LV children with ASD engaged in significantly more and longer episodes during LSJE than TD children across all three visits, but they were not significantly different from HV children with ASD.

Between-group comparisons were also conducted on the FI utterances, where a set of one-way ANOVAs was conducted to compare the percentage of each utterance type out of all utterances types (FIC, FIDB, FIDC and Other utterances) across groups. The results are displayed in Table 8. Significant group effects were obtained for both FIDC and Other utterances; Tukey's post-hoc comparisons revealed that FIDC utterances comprised a higher percentage of the utterances by the caregivers of the TD children and HV children with ASD, compared to the LV children with ASD, but overall, the FIDC utterances comprised a higher percentage of the utterances by the caregivers of the TD children than children with ASD. Other utterances comprised a greater percentage of the utterances of caregivers of the LV children with ASD, compared to the TD children, but overall, Other utterances comprised a greater percentage of the utterances of caregivers of children with ASD, compared to the TD children. Therefore, the following ANOVAs and Tukey's post-hoc comparisons will be conducted on both groups as a single group with ASD.

2. Did the episode types and utterance types differ within groups?

In order to address this question, One-way ANOVAs were conducted to compare the counts of utterance types (FIC, FIDB and FIDC) produced during the different episode types (RJA, IJA, MJA, PA, HSJE and LSJE), collapsed across the three visits. Tables 9 and 10 display the means and SDs by episode type and group. For the TD group, a significant effect of utterance type was obtained for the RJA, IJA, MJA and HSJE episodes, while for the ASD group, significant effects of utterance type were obtained for the RJA, IJA, MJA, HSJE, and LSJE episodes, and near significant effect for PA. After conducting the different ANOVAs, Tukey post-hoc comparisons were conducted, with a Bonferroni correction. That is, a p value of 0.05 was divided by the number of different comparisons, so that a p level of less than 0.002 was required to reach significance. Using this criterion, Table 9 shows the comparisons that reached the criterion level of significance of overall differences of the three utterance types in the different episode types, among both TD and ASD groups. For both groups, for most engagement states, FICs were produced by the caregivers more than FIDBs, and FIDBs were produced more than the FIDCs, therefore engagement states did not influence FIs much.

To what extent did the engagement state affects the relation between the FI utterance types? Table 10 displays the mean percentage of utterance types (FIC, FIDB, FIDC), collapsed across episode types and visits, for each group, and we are also including utterances that are not FIs (Others) for comparison. A significant effect of utterance type was obtained for both the TD and ASD groups. Tukey post-hoc comparisons were conducted, using a Bonferroni correction of a p-value of .002. Using this criterion, Table 10 shows the comparisons that reached the criterion level of significance of overall differences of the three utterance types throughout all episode types, among both TD and ASD groups. In the TD group, percentage of all utterances that are FIC is significantly more than all other types of utterances ($p<0.01$) across all episode types, and there is no significant difference in the percentage of the other utterance types during all episode types. In the ASD group, percentage of utterances that are

FIC is also significantly more than all FIDB and FIDC utterances ($p<0.01$) during all episode types; moreover, the percentage of utterances that are Others is significantly more than those that are FIDC ($p<0.01$).

A third set of one-way ANOVAs were conducted to compare the percentages of utterances produced in each episode type, collapsed across each utterance type, as displayed in Table 11. A significant main effect of episode type was obtained for both the TD and ASD groups. In general, RJA episodes included the highest percentage of utterances for both groups. Tukeys post-hoc comparisons using a Bonferroni correction of $p = 0.002$ revealed a number of significant pairwise comparisons, as listed in Table 11. With the TD group, overall, FI utterances were significantly produced more during RJA compared to all other episode types. Following RJA, FI utterances while not engaged were significantly produced more than during the other episode types, while there was no significant difference in the amount of utterances produced during MJA, PA, IJA, HSJE and LSJE. With the ASD group, overall, FI utterances were significantly produced more during RJA compared to all other episode types. Following RJA, FI utterances while not engaged were significantly produced more than during the other episode types. Following Others, FI utterances during were significantly produced more than during the other episode types, while there was no significant difference in the amount of utterances produced during MJA, IJA, HSJE and LSJE.

3. Bivariate relations between early socio-pragmatic and data-driven input measures with later vocabulary output measures

The third research question considered the relationships between the duration of the different episode types, as well as the different utterance types, across the first three visits, and the children's receptive and expressive language at visit 6, as well as SB at visit 4. Pairwise correlations were computed to investigate potential relationships between the caregivers' input variables (amount of time spent in RJA, IJA, MJA, PA, HSJE and LSJE, and average number of FIC, FIDB and FIDC utterances,

and percentage of utterances produced across the different episode types) and among the children's language outcome variables (total nouns types and tokens at visit 6, total verbs types and tokens at visit 6, MLU at visit 6, SB at visit 4, and Mullen Expressive and Receptive Languages at visit 6). A total of 136 correlation measures were calculated for both the TD and ASD groups, and because these are just exploratory correlations, Bonferroni correction was not conducted. Moreover, in order to control for unique contributions of initial cognitive and language skills, children's cognitive ability as measured by the Mullen Visual Reception subscale at visit 1, expressive language as measured by the Mullen Expressive Language subscale at visit 1, and receptive language as measured by the Mullen Receptive Language subscale at visit 1, were all partialled out. Correlation coefficients and significance levels for each significant correlation are presented in Table 12 for the TD group, and Table 13 for the ASD group.

The correlation analyses demonstrated that for TD children, children who engaged longer in IJA episodes in visits 1 to 3, had higher Mullen expressive and receptive language scores at visit 6. Children who engaged longer in PA episodes in visits 1 to 3, had lower Mullen receptive language scores at visit 6. Children who engaged more in HSJE in visits 1 to 3, produced fewer verb tokens and types, and had lower MLU, at visit 6. Children who received more FIC and FIDC utterances from their caregivers in visits 1 to 3, had higher Mullen expressive language scores at visit 6. Children who received more utterances from their caregivers that were not Follow-Ins in visits 1 to 3, had lower Mullen receptive language scores at visit 6. Children who received more FI utterances from their caregivers during IJA in visits 1 to 3, produced more noun types, and had higher Mullen expressive and receptive language scores at visit 6. Children who received more FI utterances from their caregivers during PA in visits 1 to 3, had lower Mullen receptive language scores at visit 6. Children who received more FI utterances from their caregivers during HSJE in visits 1 to 3, produced less verb tokens and types, and less MLU at visit 6. Children who received more FI utterances from their caregivers during

LSJE in visits 1 to 3, produced less noun types and verb tokens at visit 6. In other words, IJA time, FIC, FIDC, and percentage FI utterances produced during IJA were facilitative of later language, whereas PA and HSJE times, utterances that are not FI, and percentage FI utterances produced during PA, HSJE and LSJE were associative with weaker child language at visit 6.

For children with ASD, Children who engaged more in IJA in visits 1 to 3, produced more noun types and tokens, more verb types and tokens, had higher MLU, had higher SB scores, and had higher Mullen expressive and receptive language scores at visit 6. Children who engaged more in RJA in visits 1 to 3, produced more noun types and tokens, more verb types and tokens, had higher MLU, and had higher Mullen expressive and receptive language scores at visit 6. Children who engaged more in PA in visits 1 to 3, produced less noun types and tokens, less verb types and tokens, had lower MLU, had lower SB scores, and had lower Mullen expressive and receptive language scores at visit 6. Children who received more FIC utterances from their caregivers in visits 1 to 3, had higher Mullen receptive language scores at visit 6. Children who received more FIDC utterances from their caregivers in visits 1 to 3, produced more noun tokens and types, and had higher Mullen expressive and receptive language scores at visit 6. Children who received more utterances from their caregivers that were not Follow-Ins in visits 1 to 3, produced less noun types and tokens, less verb types and tokens, had lower MLU, and had lower Mullen expressive and receptive language scores at visit 6. Children who received more FI utterances from their caregivers during IJA and RJA in visits 1 to 3, produced more noun types and tokens, more verb types and tokens, had higher MLU, and had higher Mullen expressive and receptive language scores at visit 6. Children who received more FI utterances from their caregivers during PA in visits 1 to 3, produced less noun types and tokens, less verb types and tokens, had lower MLU, had lower SB scores, and had lower Mullen expressive and receptive language scores at visit 6. Children who received more FI utterances from their caregivers during LSJE in visits 1 to 3, produced less noun tokens (near significant), less verb tokens and types, and had lower Mullen receptive

language scores at visit 6. Children who received more FI utterances from their caregivers that were not during any episode type in visits 1 to 3, produced less noun types and tokens, less verb types and tokens, had lower MLU, and had lower Mullen expressive and receptive language scores at visit 6. In other words, IJA and RJA times, FIC, FIDC, and percentage FI utterances produced during IJA, RJA and MJA were facilitative of later language, whereas PA time, utterances that are not FI, and percentage FI utterances produced during PA, LSJE, and when not engaged at all were associative with weaker child language at visit 6.

4. Hierarchical Regression Analyses

Based on the results of the correlations, multiple regressions were performed, to investigate which JA and SJE measures, and which follow-in measures significantly predicted later vocabulary levels at visit 6, as well as shape bias at visit 4, after controlling for the children's cognitive ability and receptive and expressive language levels at visit 1. Table 14 shows the means and standard deviations for all the outcome measures at visit 6 (as well as SB at visit 4), in order to compare the variance of the outcome measures among all 3 groups and see to what degree does such variance explain the significance in the regression analyses conducted. Only two significant models were obtained for the TD children; namely, the percentage of FI maternal utterances during IJA across visits 1 to 3 positively predicted Mullen Expressive Language at visit 6. Also, average maternal utterances produced that were not follow-ins across visits 1 to 3 negatively predicted Mullen Receptive Language at visit 6. The significant models are presented in Table 15.

A number of significant models were obtained for the ASD children. In order to test Haebig et al.'s (2013) hypothesis and see if I will replicate their findings, regression models were obtained for both the ASD group as a whole (which are presented in Table 16), as well as for the ASD group divided into HV and LV groups, because of the considerable variation within the ASD group. For both ASD groups, the significant and near-significant models are presented in Tables 17 and 18. In the ASD group

overall, percentage of FI maternal utterances during IJA, as well as Average maternal utterances that are FIDC across visits 1 to 3 positively predicted child noun tokens and child noun types at visit 6. IJA and RJA time across visits 1 to 3 positively predicted child verb tokens at visit 6. IJA time across visits 1 to 3 positively predicted child verb types at visit 6. Percentage of FI maternal utterances during RJA, as well as IJA time across visits 1 to 3 positively predicted child MLU at visit 6. Percentage of FI maternal utterances during MJA across visits 1 to 3 positively predicted Mullen Expressive Language at visit 6. Finally, Percentage of FI maternal utterances during IJA across visits 1 to 3 positively predicted Mullen Receptive Language at visit 6. In other words, caregivers who spent more time during IJA and RJA, and produced more FI utterances during IJA, RJA and MJA, and produced FIDC utterances overall, had children who produced more nouns types and tokens, more verbs types and tokens, and more MLU at visit 6, and had higher Mullen Receptive and Expressive language scores at visit 6.

For the HV group, Average maternal utterances that are not follow-ins negatively predicted child MLU at visit 6.

For the LV group, Percentage of FI maternal utterances during IJA across visits 1 to 3 positively predicted child noun tokens at visit 6. IJA time across visits 1 to 3 positively predicted child verb tokens and verb types at visit 6. Percentage of FI maternal utterances during MJA across visits 1 to 3 positively predicted child MLU and Mullen Expressive Language at visit 6. IJA time across visits 1 to 3 positively predicted Mullen Receptive Language at visit 6. Percentage of FI maternal utterances during PA across visits 1 to 3 negatively predicted SB at visit 4, whereas Percentage of FI maternal utterances during IJA across visits 1 to 3 positively predicted SB at visit 4. In other words, caregivers who spent more time during IJA, and produced more FI utterances during IJA and MJA, had children who produced more nouns tokens, more verbs types and tokens, and more MLU at visit 6, and had higher Mullen Receptive and Expressive language scores at visit 6, as well as higher SB scores at visit

4, while caregivers who produced more FI utterances during PA, had children who had lower SB scores at visit 4.

Chapter 4: Discussion

This study investigated (a) whether there are group effects on both JA/SJE episode types and FI utterances, (b) whether both the JA/SJE episode types and FI utterances differed within groups, (c) the relation between the early social-pragmatic and data-driven measures and the later output measures, and (d) whether the early social-pragmatic and data-driven measures predict later language development in both TD children and children with ASD. All of the points mentioned above are based on 30-minute parent-child play sessions that were videotaped at each of four visits, four months apart.

Group effects on JA/SJE episode types and FI utterances

Group comparisons of the JA/SJE measures revealed that the HV children with ASD were similar to the TD children in number and duration of RJA episodes in which both groups of children engaged in with their caregivers. However, they engaged in fewer number and duration of IJA episodes. Also, LV children with ASD engaged in significantly more and longer PA episodes compared to both HV children with ASD and TD children, and they also engaged in significantly more and longer LSJE episodes than the TD children.

With regards to the FI utterances, caregivers of the TD children and HV children with ASD produced more FI utterances that were FIDC, compared to the LV children with ASD, whereas the caregivers of the LV children with ASD produced more utterances that were Others, compared to the TD children.

FIDC utterances were produced a greater percentage of the time by the caregivers of the TD children and HV children with ASD, compared to the LV children with ASD, and Other utterances were produced a greater percentage of the of the time by caregivers of the LV children with ASD, compared to the TD children.

Overall, these findings suggest that there are more similarities in the amount and duration of JA/SJE episode types, as well as the amount of FI utterances, between the TD group and the HV

children with ASD, compared to the LV children with ASD. These findings are consistent with my hypothesis; that TD children would be similar to HV children with ASD, and that both of these groups of children would be different from LV children with ASD.

Differences between JA/SJE episode types and FI utterances within groups

Caregivers of both groups produced the highest proportion of FI utterances during RJA, and the lowest during IJA (for both groups with ASD) and during LSJE (for the TD group). Caregivers of children with ASD produced significantly greater proportions of FI utterances during LSJE, PA, and Other, while caregivers of TD children produced significantly greater proportions during RJA and IJA. Collapsed across engagement types, caregivers of both groups produced their highest proportion of FI utterances as FICs (~50%) compared to FIDBs and FIDCs (~25% each). Caregivers in both groups produced significantly higher FIC, FIDB, and FIDC proportions during RJA episodes than during all other engagement types. Caregivers of children with ASD uniquely also produced many FI utterances during PA episodes and when disengaged.

Overall, caregivers in both groups talked relatively more during RJA, produced relatively more FICs overall, and emphasized FICs across all engagement types. Caregivers of children with ASD produced relatively more utterances and provided more Follow-in content during less-engaged or disengaged episodes (LSJE, PA, and Other), while caregivers of the TD group produced relatively more utterances and provided more Follow-in content during more engaged episodes (RJA and IJA). This is also in line with my hypothesis; that caregivers of TD children produce more FI utterances than both groups of children with ASD.

Relation between the early social-pragmatic and data-driven measures and the later output measures

The correlation analyses demonstrated that for all groups, children who engaged more in IJA and RJA, and received more FI utterances from their caregivers during IJA, RJA and MJA, as well as FIC and FIDC utterances, during the first three visits, had higher language scores at visit 6. On the

other hand, children who engaged more in PA, HSJE (for the TD group), and LSJE (for the ASD group), and received more FI utterances from their caregivers during PA, HSJE (for the TD group), LSJE (for the ASD group) and Others during the first three visits, had lower language scores at visit 6. Interestingly, HSJE and LSJE episodes did not elicit higher FI utterance proportions, contrary to Bottema-Beutel et al.'s (2014) findings that these episodes could provide additional communication scaffolds for children with ASD.

Predicting later language development from early social-pragmatic and data-driven measures

The results from the hierarchical regression analyses suggest that duration of time in IJA, as well as caregiver FI utterances produced during IJA, were strong positive predictors of later vocabulary development in both TD children and children with ASD, along with RJA time and FI utterances produced during RJA, and utterances produced during MJA (for ASD group overall), while utterances produced during PA, as well as utterances produced that were not FIs, were negative predictors for later vocabulary development in both TD children and children with ASD. Also, when the ASD group is divided into HV and LV children with ASD, we find significant differences between the two groups. For the HV children with ASD, average maternal utterances that are not FIs was the only measure that negatively predicted child MLU at visit 6. For the LV children with ASD, percentage of FI caregiver utterances during IJA and MJA, as well as IJA time, were strong positive predictors for later vocabulary development, while the percentage of FI caregiver utterances during PA was a negative predictor for later vocabulary development.

Overall, these findings suggest that when children spend more time in more engaged episode types, such as during IJA and RJA, as well as receive more FIs during these more engaged episode types, such as IJA in particular, as well as RJA and MJA, their language scores are higher. On the other hand, when children spend more time in less-engaged episode types, such as PA, as well as receive more FIs during these less engaged episode types (or if not engaged at all), their language scores are

lower. These findings also suggest that when HV children with ASD receive more FIs during the less engaged episode types (or if not engaged at all), their language scores are lower. Also, these findings suggest that when LV children with ADS spend more time in IJA, as well as receive more FIs during IJA and MJA, their language scores are higher, whereas when they receive more FIs during PA, their language scores are lower. Finally, these findings suggest that the TD group and the HV group with ASD have similar findings, and both are distinct from the findings of the LV group with ASD; i.e. there are more predictors for later language for the LV group with ASD, compared to both the HV group with ASD and the TD group.

The variance of the outcome measures presented in Table 14 demonstrate that the LV group with ASD had relatively lower means and SDs in all of the outcome measures, except in MLU and Mullen Expressive and Receptive languages at visit 6, compared to the variance in the outcome measures of both the HV group with ASD, as well as the TD group. Still, the means and SDs of the LV group with ASD was lower than the HV group with ASD. On careful analysis of the variance and the regression models, we find that there were three outliers in the LV group with ASD (using Cook's distance), and when we removed them from our data and reconducted the regression analyses, the models were still significant, and the means and SDs of all the outcome measures of the LV group with ASD were lower than the HV group with ASD and the TD group. Therefore, the low variance in the LV group with ASD suggest that the regressions in this group cannot be explained by the variance within the group. Also, even though the TD group and the HV children with ASD had a larger variance in their outcome measures, there were no models that predicted the later language outcomes of these two groups.

Overall, these findings are also in line with my hypothesis regarding the role the different episode types and FI utterances play in predicting later vocabulary development of children in both groups. These factors play a larger role with the LV children with ASD, compared to the HV children

with ASD and the TD children, suggesting that the lower the initial language levels of the children, the greater the role these factors play in predicting their later vocabulary levels.

In the following sections, each of attention/engagement and language findings, as well as the relationship between them, will be discussed in relation to the hypotheses presented in the introduction section.

The findings presented earlier suggest that even though they demonstrate that the socio-pragmatic aspects of language plays a larger role with the three groups of children in this study, the effects of the socio-pragmatic aspects are based on the children's initial language levels. The lower their initial language levels, the greater the socio-pragmatic aspects predict later vocabulary development, whereas the higher the children's initial language levels, the less the socio-pragmatic aspects play a role in predicting both vocabulary and syntactic development, and perhaps the data-driven aspects begin to play a larger role in the children's vocabulary and syntactic development. With regards to FI utterances, the findings by Haebig et al. (2013) regarding the unique effects of FI utterances independently in any group were not replicated. Rather, the findings suggest that the effects of FI utterances on later language depended on the episode type in which they are produced. Therefore, these FI utterances should be considered as socio-pragmatic measures, rather than data-driven measures, suggesting that the role of the data-driven aspects of word learning have not been tested in this study, and in order to fully compare between the socio-pragmatic and data-driven aspects of word learning, the data-driven measures used by Hoff and Naigles (2002) will be used. Hoff and Naigles (2002) showed that with the TD group, the data-driven measures (such as caregiver MLU, word types and word tokens, and total number of utterances) were better predictors of later language. The same data-driven aspects measures used by Hoff and Naigles (2002) will be used in a future study to fully compare the TD children and children with ASD, and therefore test the hypothesis regarding the role of the data-driven aspects at a later stage.

A. The Socio-pragmatic and Data-driven aspects of word learning

This study showed that the socio-pragmatic aspects played a larger role in later vocabulary development of children, in comparison to the findings in Hoff and Naigles' (2002) findings. However, on careful analysis of the findings of both studies, I suggest that the findings are complementary to each other. In this study, it has been demonstrated that the socio-pragmatic aspects played a larger role with the LV children with ASD, compared to the HV children with ASD and the TD children. These findings suggest that the lower the initial language levels of the children, the more interactions the children need in the different social contexts, in order to correctly map the new words to the correct target object. When the children's vocabulary levels increase, the children become more able to figure out word meanings from the structural properties of the utterances themselves, and therefore the data-driven aspects play a larger role, as demonstrated in Hoff and Naigles' (2002) study. For example, earlier in the child's development, in order to learn words such as "baby", "feed the baby", "milk", etc., the child needs to be engaged with his/her caregiver and play with the bus toys, and receive FIs.

The following is an example of an interaction between the caregiver of a HV child with ASD at visit 1:

1. Mother: oh baby . (Mother brings baby toy for child to imaginary feed.)
2. Mother: feed the baby .
3. *Child responds*
4. Mother: ahh .
5. Mother: okay .
6. Mother: where's the milk?
7. *Child picks up the bottle.*

In this particular episode of RJA, on lines 3 and 7, the child is engaged and responds to the mother's bids, and during their interaction, the mother in lines 2 and 6 introduces the words "baby"

"feed" and "milk". The more the child received FIs during these kinds of episodes (IJA, RJA and MJA in particular, and especially if the child is LV with ASD), the larger their vocabulary score was at visit 6. The following is example of an interaction between the caregiver and a LV child with ASD, this time in an IJA episode:

1. *Child gives book to mother*
2. Mother: no you wanna look at the book .
3. *Child nods*
4. Mother: what's that ?
5. *Child looks, but does not respond verbally.*
6. Mother: what's that ?
7. *Child looks, but does not respond verbally.*
8. Mother: cat says meow, meow .
9. *Child smiles*
10. Mother: that's a dog they go, woof woof woof .
11. *Child smiles*
12. Mother: that's his tail .
13. *Child smiles*
14. Mother: doggies tail waggle waggle waggle tail .
15. *Child smiles*

In this particular episode of IJA, the child in lines 1, 3, 5, 7, 9, 11, 13 and 15 is engaged and responds to the mother's bids, even though she doesn't respond verbally, and during their interaction, the mother in line 8 introduces the words "cat" and "meow", in line 10 introduces "dog" and "woof", in line 2 introduces "book", in line 12 introduces "tail", and in line 14 introduces "waggle". Again, the more the child received FIs during these kinds of episodes, the larger their vocabulary score was at visit

6. TD children and HV children with ASD spent significantly more time during RJA than the LV children with ASD. TD children also spent significantly more time during IJA than both groups of children with ASD.

In contrast to the examples above, the following is an example of a different interaction between the caregiver and the same LV child with ASD mentioned above, this time in a PA episode:

1. Mother: should we do the balloon ?

2. Mother: can I blow the balloon ?

3. Mother: ah look, look what I have ?

4. Mother: wow where did it go ?

5. *Child does not respond at all during this episode.*

In this interaction, the child is not engaged. This engagement state is not helping her learn words such as "balloon" in lines 1 and 2, even though the mother is Following-In onto the child's focus on attention. The more the LV children engage in these types of episodes (where they are less engaged or not engaged), the lower their language scores at visit 6. LV children with ASD spent significantly more time during PA than TD children and HV children with ASD. LV children with ASD also spent significantly more time during LSJE than TD children.

To confirm the later role of the data-driven aspects, the data-driven measures used in Hoff and Naigles' (2002) study (caregiver's total number of utterances, word tokens, word types, and MLU) will be used in the two groups in this study for comparison.

B. Joint Attention/Supported Joint Engagement and Language development

This study replicated previous research with regards to JA as a predictor of later language abilities in both TD children and children with ASD (e.g. Mundy et al., 1986, Mundy, Sigman and Kasari, 1990, Mundy and Gomes, 1998), after controlling for non-verbal IQ and early language at visit 1. In addition to these findings, this study showed that the FI utterances produced during IJA, RJA and

MJA were strong predictors of later vocabulary development at visit 6, suggesting that FIs produced during these episode types are the most beneficial to the children for their vocabulary development.

In contrast, this study did not replicate previous research regarding SJE as a predictor of later language abilities in both TD children and children with ASD (e.g Adamson et al., 2004, 2009), even after dividing SJE into HSJE and LSJE (Bottema-Beutel et al., 2014). One possible explanation is that in these studies, the researchers did not compare SJE episodes with JA episodes in the same study. In the studies by Adamson et al. (2004, 2009), the researchers used "Coordinated Joint Engagement" (CJE) in their framework. Bakeman and Adamson (1984) defined CJE as an episode where the child is actively involved with and coordinates his/her attention between the caregiver and the object. For example, the child pushes the car the mother has been pushing, and then looks back and forth between the mother's face and the car. In the current study, this type of episode would have been coded as RJA. Another example that is also mentioned by Bakeman and Adamson (1984) is when the child bangs his hand onto the same toy the caregiver is manipulating, and then looks at the caregiver, bangs the toy, and then looks at the caregiver once again. In the current study, this type of episode would have also been coded as RJA. A third example is when the child looks at the caregiver's face when he/she accepts the puzzle piece, glancing towards the caregiver with a smile when the piece is correctly placed. This would also be coded as RJA. In all three examples, the caregiver initiates the episode, and the child responds accordingly. Perhaps it might be the case that in coding for CJE, most of these episodes are RJAs, therefore missing other episode types such as IJA, and as shown in this study and in previous studies in the literature, IJA is a strong predictor of later language abilities in both TD children and children with ASD. Still, CJE was coded only in Adamson et al.'s (2004, 2009) studies, while it was not coded in Bottema-Beutel et al.'s (2014) study.

The current study supported Bottema-Beutel et al.'s (2014) study regarding the division between HSJE and LSJE, since there are differences in the amount of time spent in the two different

episode types, and there are differences with regards to their correlation with later language scores (even though they did not predict later language scores). The current study also supported the concept that the effects of FI utterances on later language are based on the episode type, rather than independent of the different episode types, as Haebig et al. (2013) demonstrated. However, the current study extended the findings by Bottema-Beutel et al. (2014) to other JA episode types, as well as with other populations, such as TD children. Since HSJE and LSJE are now compared with the other JA types, this study did not support Bottema-Beutel et al.'s (2014) findings on the role of HSJE and LSJE with FI utterances in later vocabulary development. However, Bottema-Beutel et al. (2014) also found that HSJE with FI utterances predicted later communication, so perhaps the SJE framework plays a larger role in communication (where the child can communicate his/her needs without necessarily using words, such as using pointing to show or request an object), rather than in later language development. This current study did not look into the role of JA and SJE episode types in communication.

C. Follow-in Utterances and Language Development

The current study did not replicate the findings in Haebig et al.'s (2013) study, demonstrating that the FI utterances did not independently predict later language development in all groups. FICs are produced by the caregivers (≈ 50%) significantly more than FIDBs and FIDCs (≈ 25% each). However, all of the FI utterances are scattered and produced in the different episode types, and this study did find that the FI utterances produced during IJA, RJA and MJA predicted later language scores at visit 6. So perhaps the FI utterances play a role in later vocabulary scores, but *within* the episode types, rather than independently regardless of the episode type. This explanation further strengthens the hypothesis that the effect of FI utterances depends on when such utterances are produced, and is similar to one of the socio-pragmatic measures used by Hoff and Naigles (2002) (where they used the number of overall maternal utterances produced during episodes of joint attention in general). As shown in part A of this section with the 3 different interactions regarding the role of the socio-pragmatic and data-driven

aspects of word learning, FI utterances produced during IJA positively predicted later language levels at visit 6, while FI utterances produced during PA negatively predicted later language levels at visit 6.

Overall, the findings in this study did not replicate the findings in Haebig et al.'s (2013) study, but it still showed that FI utterances are strong predictors for later vocabulary development, as McDuffie and Yoder (2010), Yoder et al., (2015), and Yoder and Watson (2017) have previously demonstrated.

D. Autism and Language Development

As mentioned earlier in the introduction section, empirical evidence suggests that JA impairment in children with autism affects their language skills (e.g. Carpenter et al., 1998; Morales et al., 2000; Mundy & Gomes, 1998; Stone & Yoder, 2001), and Baron-Cohen et al. (1997) and Preissler and Carey (2005) showed that children with autism use their own focus of attention, rather than the caregiver's focus of attention, leading to incorrect mappings between novel labels and objects. The findings in the current study suggest that the best time(s) for providing novel labels in the FI utterances are during IJA, RJA and MJA (i.e. while the children with ASD are more engaged, and within their focus of attention), in order to correctly map the novel word onto the object and learn new words. When children with ASD (especially the LV group) engage in IJA, the children's propensity (as active learners who want to learn more about the object they are playing with) to Initiate a JA episode, as well as caregivers meeting this propensity by producing utterances during IJA, were strong predictors of later language development. The same applies to the children's propensity to be engaged in a MJA episode, even if not as clear as IJA. Also, when caregivers meet the children's propensity to engage in a MJA episode by producing utterances during MJA, this interaction was a strong predictor of later language development.

E. Limitations of the study

This study has several limitations. One limitation is that despite the fact that this study showed via the regressions that FI utterances produced during IJA, RJA and MJA positively predicted later vocabulary scores, one cannot claim that there is a causal relation between FI utterances during JA episode types and later language levels. In order to determine any causal relationship, several relationships should be investigated, such as between FI utterances and factors such as: Caregiver characteristics and the children's early language and social status (which drives the interactions of the caregivers with their children in a certain way, e.g. caregivers talking more or less to their children). Another limitation is that although FI utterances were suggested as a measure for the data-driven aspects of caregiver input (based on the different types of FI utterances), there are other data-driven measures that should still be used, such as those used in Hoff and Naigles' (2002) study, in order to make an accurate comparison regarding the predictive value of the data-driven and socio-pragmatic aspects, in relation to later vocabulary development.

F. Final Conclusions

This study compared between the roles of the socio-pragmatic and data-driven aspects of caregiver input in the later vocabulary development of both TD Children and children with ASD, and looked into the role of JA, SJE and FI utterances in the vocabulary development of TD Children and children with ASD. Overall, IJA, RJA and MJA, as well as the FI utterances that were produced during these three episode types during the first three visits, significantly predicted later receptive and expressive language scores at visit 6, while utterances produced during PA, as well as utterances that were not FIs, negatively predicted later receptive and expressive language scores at visit 6. SJE measures did not predict later vocabulary scores, as shown in previous literature. The findings suggest that in these groups of children, the socio-pragmatic aspects played a larger role with LV children with ASD, whereas it played a milder role with both HV children with ASD, as well as with the TD children. These findings replicated the studies that showed the importance of IJA and RJA as strong

predictors for later language abilities in both TD children and children with ASD. These findings also replicated the studies that showed the importance of FI utterances as strong predictors for later language abilities in children with ASD, especially the FI utterance that are produced during the IJA, RJA and MJA episode types. One important implication of these findings is that there needs to be more research conducted in order to figure out how to create opportunities to make the child more engaged, so that the FI utterances provided while the child is more engaged lead to greater language outcomes, especially for the LV children with ASD. Another important implication of these findings is that for LV children with ASD, caregivers need to Follow-In as soon as the children show interest in any toy or object.

References

Adamson, L. B., & Bakeman, R. (1998). *The communication play protocol (Tech. Rep. No. 8).* Atlanta: Georgia State University, Department of Psychology.

Adamson, L. B., & Bakeman, R. (1999). Viewing variations in language development: The communication play protocol. *Augmentive and Alternative Communication, 8,* 2–4.

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

Adamson, L. B., Bakeman, R., Deckner, D. F., & Nelson, P. B. (2014). From Interactions to Conversations: The Development of Joint Engagement During Early Childhood. *Child Development, 85* (3), 941–955. doi: 10.1111/cdev.12189

Adamson, L. B., Bakeman, R., Deckner, D. F., & Romski, M. (2009). Joint engagement and the emergence of language in children with autism and down syndrome. *Journal of Autism and Developmental Disorders, 39* (1), 84–96.

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

Akhtar, N., Dunham, F., Dunham, P. (1991). Directive interactions and early vocabulary development: the role of joint attentional focus. *Journal of Child Language, 18* , 41–49.

Aslin, N., Saffran, J., & Newport, E. (1999). Statistical learning in linguistic and nonlinguistic domains. In B. MacWhinney (Ed.), *The emergence of language* (pp. 359–380). Mahwah, NJ: Lawrence Erlbaum Associates.

Bakeman, R., & Adamson, L. B. (1984). Coordinating attention to people and objects in mother-infant and peer-infant interaction. *Child development, 55,* 1278–1289. doi:10.2307/1129997

Baldwin, D. A. (1991). Infants' contribution to the achievement of joint reference. *Child Development, 62,* 875-890.

Baldwin, D. A. (1995). Understanding the link between joint attention and language. In *Joint attention its origins and role in development* (pp. 131–158).

Baltaxe, C. a. M. (1977). Pragmatic deficits in the language of autistic adolescents. *Journal of Pediatric Psychology, 2* (4), 176–180. doi: 10.1093/jpepsy/2.4.176

Baron-Cohen, S., Baldwin, D. A., & Crowson, M. (1997). Do children with autism use the speaker's direction of gaze strategy to crack the code of language? *Child development, 68* (1), 48–57. doi: 10.2307/1131924

Bottema-Beutel, K., Yoder, P. J., Hochman, J. M., & Watson, L. R. (2014). The Role of Supported Joint Engagement and Parent Utterances in Language and Social Communication Development in Children with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders,* 2162–2174. doi: 10.1007/s10803-014-2092-z

Bruner, J. (1983). *Child's talk: Learning to use language.* Oxford: Oxford University Press. Cardenas, E. R. (2012). *Word Learning During First Language Acquisition: Linking Sounds to Referents.*

Bruner, J. S. (1975). From communication to language: A psychological perspective. *Cognition, 3,* 255–287 ST – From communication to language: A ps.

Carpenter, M., Nagell, K., & Tomasello, M. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development , 63* (4), i–vi, 1–143.

Charman, T. (1998). Specifying the Nature and Course of the Joint Attention Impairment in Autism in the Preschool Years: Implications for Diagnosis and Intervention. *Autism, 2* (1), 61–79. doi: 10.1177/1362361398021006

Cohen, H., Amerine-Dickens, M., & Smith, T. (2006). Early intensive behavioral treatment: Replication of the UCLA model in a community setting. *Journal of developmental and behavioral pediatrics: JDBP, 27* (2 Suppl), S145–S155. doi: http://dx.doi.org/10.1097/00004703-200604002-00013

Dunn, L. M., & Dunn, L. M. (1997). *Peabody picture vocabulary test* (3rd ed.). Circle Pines, MN: American Guidance Service.

Eigsti, I. M., Bennetto, L., & Dadlani, M. B. (2007). Beyond pragmatics: Morphosyntactic development in autism. *Journal of Autism and Developmental Disorders, 37* (6), 1007–1023.

Fein, D., Dunn, M., Allen, D., Aram, D., Hall, N., Morris, R., & Wilson, B. (1996). Language and neuropsychological findings. In I. Rapin (Ed.), *Preschool children with inadequate communication* (pp. 123–154). London, UK: MacKeith Press.

Fenson, L., Dale, P. S., Reznick, J. S., Thal, D., Bates, E., Hartung, J. P., & Al., E. (1993). *MacArthur Communicative Development Inventory: Words and Gestures.* San Diego, CA: Singular Publishing Group.

Gastgeb, H. Z., Strauss, M. S., & Minshew, N. J. (2006). Do individuals with autism process categories differently? The effect of typicality and development. *Child Development, 77* (6), 1717–1729. doi: 10.1111/j.1467-8624.2006.00969.x

Gomez, R. L., & Gerken, L. (1999). Artificial grammar learning by 1-year-olds leads to specific and abstract knowledge. *Cognition, 70* (2), 109–135. doi: 10.1016/S0010 -0277(99)00003-7

Haebig, E., McDuffie, A., & Ellis Weismer, S. (2013). Brief Report: Parent verbal responsiveness and language development in toddlers on the autism spectrum. *Journal of Autism and Developmental Disorders, 43* (9), 2218–27. doi: 10.1007/ s10803-013-1763-5

Harris, M., Jones, D., Brookes, S., & Grant, J. (1986). Relations between the non-verbal context of maternal speech and rate of language development. *British Journal of Developmental Psychology, 4* (3), 261–268.

Hoff, E., & Naigles, L. (2002). How children use input to acquire a lexicon. *Child development, 73* (2), 418–433. doi: 10.1111/1467-8624.00415

Hoff-Ginsberg, E. (1986). Function and structure in maternal speech: Their relation to the child's development of syntax. *Developmental Psychology, 22* (2), 155–163. doi: 10.1037/0012-1649.22.2.155

Hollich, G. J., Hirsh-Pasek, K., Golinkoff, R. M., Brand, R. J., Brown, E., Chung, H. L., Rocroi, C. (2000). Breaking the language barrier: An emergentist coalition model for the origins of word learning. *Monographs of the Society for Research in Child Development, 65* (3), i–vi, 1–123. doi: 10.1111/1540-5834.00090

Huttenlocher, J., Haight, W., Bryk, A., Seltzer, M., & Al, E. (1991). Early vocabulary growth: Relation to language input and gender. *Developmental Psychology, 27* (2), 236–248. doi: 10.1037/0012-1649.27.2.236

Huttenlocher, J., Vasilyeva, M., Cymerman, E., & Levine, S. (2002). Language input and child syntax. *Cognitive Psychology, 45* (3), 337–74. doi: 10.1016/S0010-0285(02)00500-5

Kana, R. K., Keller, T. A., Cherkassky, V. L., Minshew, N. J., & Just, M. A. (2006). Sentence comprehension in autism: Thinking in pictures with decreased functional connectivity. *Brain: A journal of neurology, 129* (Pt 9), 2484–93.

Kelley, E., Paul, J. J., Fein, D., & Naigles, L. R. (2006). Residual language deficits in optimal outcome children with a history of autism. *Journal of Autism and Developmental Disorders, 36* (6), 807–828. doi: 10.1007/s10803-006-0111-4

Lord, C., & MaGill-Evans, J. (1995). Peer interactions of autistic children and adolescents. *Development and Psychopathology, 7* (04), 611. doi: 10.1017/S095457940000674X

Lord, C., Rutter, M., Goode, S., Heemsbergen, J., Jordan, H., Mawhood, L., & Schopler, E. (1989). Austism diagnostic observation schedule: A standardized observation of communicative and social behavior. *Journal of Autism and Developmental Disorders, 19,* 185–212. doi: 10.1007/BF02211841

Lovaas, O. I. (1987). Behavioral treatment and normal educational and intellectual functioning in young autistic children. *Journal of Consulting and Clinical Psychology, 55* (1), 3–9.

Mayberry, R. I., & Eichen, E. B. (1991). The long-lasting advantage of learning sign language in childhood: Another look at the critical period for language acquisition. *Journal of Memory and Language, 30,* 486–512.

McDaniel, J., Yoder, P., Watson, L. (2017). A Path Model of Expressive Vocabulary Skills in Initially Preverbal Preschool Children with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders, 47* (4): 947–960.

McDuffie, A., & Yoder, P. (2010). Types of parent verbal responsiveness that predict language in young children with autism spectrum disorder. *Journal of speech, language, and hearing research : JSLHR, 53* (4), 1026–1039.

Moerk, E. (1994). Corrections in first language acquisition: Theoretical controversies and factual evidence. *International Journal of Psycholinguistics, 10* (1), 33–58.

Morales, M., Mundy, P., Delgado, C. E., Yale, M., Messinger, D., Neal, R., & Schwartz, H. K. (2000). Responding to Joint Attention Across the 6-Through 24-Month Age Period and Early Language Acquisition. *Journal of Applied Developmental Psychology, 21* (3), 283–298.

Mullen, E. M. (1995). Mullen Scales of Early Learning, AGS Edition: Manual and Item Administrative Books. *American Guidance Services, Inc.*, 1–92.

Mundy, P. (2009). Lessons learned from autism: an information-processing model of joint attention and social-cognition. In C. D & G. M (Eds.), *Minnesota symposia on child psychology: Meeting the*

challenge of translational research in child psychology (pp. 59–114). Hoboken, NJ: John Wiley & Sons, Inc.

Mundy, P., & Gomes, a. (1998). Individual differences in joint attention skill development in the second year. *Infant behavior and development, 21* (3), 469–482.

Mundy, P., Hogan, A., & Doehring, P. (1996). *A preliminary manual for the abridged Early Social Communication Scales.* University of Miami: Coral Gables.

Mundy, P., Sigman, M., & Kasari, C. (1990). A longitudinal study of joint attention and language development in autistic children. *Journal of autism and developmental disorders, 20* (1), 115-128

Mundy, P., Sigman, M., & Kasari, C. (1994). Joint attention, developmental level, and symptom presentation in autism. *Development and Psychopathology, 6* (03), 389. doi: 10.1017/S0954579400006003

Mundy, P., Sigman, M., Ungerer, J., & Sherman, T. (1986). Defining the social deficits of autism: the contribution of non-verbal communication measures. *Journal of child psychology and psychiatry, and allied disciplines, 27* (5), 657–669.

Naigles, L. R. (2013, nov). Input and language development in children with autism. *Seminars in speech and language, 34* (4), 237–48. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/24297616 doi: 10.1055/s-0033-1353446

Naigles, L. R., Chin, I. (2015). Language in children with autism spectrum disorders. In E. L. Bavin & L. R. Naigles (Ed.s), *The Cambridge Handbook of Child Language* (2nd ed., pp. 637–658). http://dx.doi.org/10.1055/s-0033-1353446

Naigles, L. R., Fein, D. (2017). Looking Through Their Eyes: Tracking Early Language Comprehension in ASD. In Naigles, L. R. (Ed.), *Innovative Investigations of Language in Autism Spectrum Disorder* (pp. 49–69). APA and De Gruyter Mouton, Washington, DC.

Naigles, L. R., Tovar A. T. (2012). Portable Intermodal Preferential Looking (IPL): investigating language comprehension in typically developing toddlers and young children with autism. *J. Vis. Exp.* 70:e4331.

Potrzeba, E. R., Fein, D., & Naigles, L. (2015). Investigating the shape bias in typically developing children and children with autism spectrum disorders. *Frontiers in Psychology, 6* (4), 446. http://doi.org/10.3389/fpsyg.2015.00446

Preissler, M. A., & Carey, S. (2005). The role of inferences about referential intent in word learning: Evidence from autism. *Cognition, 97* (1), B13–23. doi: 10.1016/ j.cognition.2005.01.008

Ratner, N., & Bruner, J. (1978). Games, social exchange and the acquisition of language. *Journal of child language, 5*, 391–401. doi: 10.1017/S0305000900002063

Saffran, J. R., & Wilson, D. P. (2003). From Syllables to Syntax : Multilevel Statistical Learning by 12-Month-Old Infants. *Infancy, 4* (2), 273–284. doi: 10.1207/S15327078IN0402_07

Schopler, E., Reichler, R., & Renner, B. (1988). *The Childhood Autism Rating Scale.* Los Angeles, CA: Western Psychological Services.

Seibert, J., Hogan, A., & Mundy, P. (1982). Assessing interactional competencies The early social-communication scales. *Infant Mental Health Journal, 3*, 244–258. doi: 10.1002/1097-0355(198224)3:4<244::AID-IMHJ2280030406>3.0.CO;2-R

Sigman, M., Ruskin, E., Arbeile, S., Corona, R., Dissanayake, C., Espinosa, M., Zierhut, C. (1999). Continuity and change in the social competence of children with autism, Down syndrome, and developmental delays. *Monographs of the Society for Research in Child Development, 64* (1), 1–114.

Siskind, J. M. (1996). A computational study of cross-situational techniques for learning word-to-meaning mappings. In M. R. Brent (Ed.), *Computational approaches to language acquisition* (pp. 39–91). Cambridge, Massachusetts: MIT Press.

Skuse, D. (1988). Extreme deprivation in early childhood. In D. Bishop & K. Mogford (Eds.), *Language development in exceptional circumstances* (pp. 29–46). Edinburgh: Churhill Livingstone.

Smith, L. (2000). Learning how to learn words: An associative crane. In *Becoming a word learner: A debate on lexical development* (pp.51-80). New York: Oxford University Press.

Sparrow, S., Cicchetti, D., & Balla, D. (2005). *Vineland Adaptive Behavior Scales: Second Edition (Vineland II), Survey Interview Form/Caregiver Rating Form.* Livonia, MN: Pearson Assessments.

Stone, W. L., Hoffman, E. L., Lewis, S. E., & Ousley, O. Y. (1994). Early recognition of autism. Parental reports vs clinical observation. *Archives of Pediatrics & Adolescent Medicine, 148* (2), 174–179. doi: 0.1001/archpedi.1994.02170020060010

Stone, W. L., & Yoder, P. J. (2001). Predicting Spoken Language Level in Children with Autism Spectrum Disorders. *Autism, 5* (4), 341–361. doi: 10.1177/1362361301005004002

Swensen, L., Kelley, E., Fein, D., & Naigles, L. (2007). Processes of language acquisition in children with autism: Evidence from preferential looking. *Child Development, 78* (2), 542-557.

Tager-Flusberg, H. (1996). Brief report: Current theory and research on language and communication in autism. *Journal of autism and developmental disorders, 26* (2), 169–172. doi: 10.1007/BF02172006

Tager-Flusberg, H. (2004). Strategies for conducting research on language in autism. *Journal of autism and developmental disorders, 34* (1), 75–80.

Tager-Flusberg, H., Calkins, S., Nolin, T., Baumberger, T., Anderson, M., & Chadwick-dias, A. (1990). A longitudinal study of language acquisition in autistic and Down syndrome children. *Journal of Autism and Developmental Disorders, 20* (1), 1–21.

Tager-Flusberg, H., Paul, R., & Lord, C. (2005). Language and Communication in Autism. In F. R. Volkmar, R. Paul, A. Klin, & D. J. Cohen (Eds.), *Handbook of autism and pervasive developmental disorders* (Vol. 1, pp. 335–364). Wiley.

Tamis-LeMonda, C. S., Bornstein, M. H., & Baumwell, L. (2001). Maternal responsiveness and children's achievement of language milestones. *Child development, 72* (3), 748–767. doi: 10.1111/1467-8624.00313

Tek, S., Jaffery, G., Fein, D., & Naigles, L. R. (2008, aug). Do children with autism spectrum disorders show a shape bias in word learning? *Autism research: Official journal of the International Society for Autism Research, 1* (4), 208–22.

Tek, S., Mesite, L., Fein, D., & Naigles, L. (2014). Longitudinal analyses of expressive language development reveal two distinct language profiles among young children with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 44* (1), 75–89. doi: 10.1007/s10803-013-1853-4

Tomasello, M. (1988). The role of joint attentional processes in early language development. *Language Sciences, 10* (1), 69–88. doi: 10.1016/0388-0001(88)90006-X

Tomasello, M., & Todd, J. (1983). Joint attention and lexical acquisition style. *First Language, 4* (12), 197–211.

Tovar, A. T., Fein, D., & Naigles, L. R. (2015). Grammatical Aspect Is a Strength in the Language Comprehension of Young Children With Autism Spectrum Disorder. *Journal of speech, language, and hearing research: JSLHR2, 58* (2), 301–310. doi: 10.1044/2014

Trevarthen, C., & Hubley, P. (1978). Secondary Intersubjectivity: Confidence, confiding and acts of meaning in the first year. In A. Lock (Ed.), *Action, gesture and symbol: The emergence of language* (pp. 183–229). Academic Press.

Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes* (14th ed., Vol. 1). Harvard University Press.

Wetherby, A. M., & Prizant, B. M. (2002). *CSBS DP manual* (First norm ed.). Baltimore, MD: Paul H. Brookes Publishing Co.

Williams, K. T. (1997). *Expressive vocabulary test.* Circle Pines, MN: American Guidance Service.

Yoder, P., Watson, L., & Lambert, W. (2015). Value-added predictors of expressive and receptive language growth in initially nonverbal preschoolers with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 45,* 1254-1270. doi:10.1007/s10803-014-2286-4.

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

Table 1. *M* and *SD* of scores of TD and ASD groups on standardized tests at visit 1.

	ASD			**TD**			
	n = 31			*n* = 33			
	M	SD	Range	*M*	SD	Range	*d*
Age in months	32.9	5.5	18.8 – 41.07	20.3	1.63	18.3 – 23.73	0.298
CDI	222.3	171.7	3 – 684	316.97	159.6	157 – 677	0.571
ADOS[1]	14.03	4.01	7 – 21	0.85	1.52	0 – 5	4.346
Vineland	75.9	16.9	52 – 113	104.97	8.81	94 – 131	2.157
Communication[2]							
V1							
Vineland Daily	78	13.9	55 – 117	104.45	8.73	88 – 119	2.279
Living Skills							
Vineland Social	73.5	7.65	61 – 93	101.03	6.70	86 – 115	3.829
Vineland Motor	84.6	13.1	64 – 111	100.21	6.83	84 – 111	1.494
Mullen Visual							
Reception V1							
Raw	27.4	5.22	20 – 42	26.07	3.53	19 – 32	0.298

	ASD			TD			
	n = 31			*n* = 33			
	M	SD	Range	*M*	SD	Range	*d*
scores							
t scores	37.58	14.85	20 – 65	58.70	9.95	36 – 80	1.671
Mullen Fine							
Motor V1							
Raw	25.2	4.04	20 – 34	22.73	2.58	19 – 28	0.729
scores							
t scores	33	14.71	20 – 76	50.64	8.81	36 – 75	1.455
Mullen							
Receptive							
Language V1							
Raw	19.3	10.10	2 – 38	23.2	3.80	17 – 27	0.511
scores							
t scores	35.81	18.82	20 – 74	58.12	11.52	28 – 80	1.430
Mullen							
Expressive							

	ASD			TD			
	n = 31			*n* = 33			
	M	SD	Range	*M*	SD	Range	*d*
Language V1							
Raw	16.47	6.44	8 – 30	20.8	5.83	13 – 33	0.705
scores							
t scores	30.52	12.6	20 – 64	50.15	12.88	30 – 80	1.541

[1] Cut-off score for a diagnosis of autism is 12, and cut-off score for a diagnosis of autism spectrum disorders is 7.

[2] Vineland scores represent standard scores: $M = 100$, $SD = 15$.

Table 2. The coding scheme for JA and PA adapted from Roos et al. (2008) comparing adult and child behaviors during a JA episode in ECSC vs. parent-child play sessions.

ESCS

RJA	**IJA**
A. Adult's behavior	**Child's behavior**
1. Adult points proximally to a page of a picture book	1. Eye contact
2. Adult looks and points distally toward a poster on the wall while calling the child's name	2. Alternating/referencing
	3. Pointing
	4. Showing
B. Child's behavior	
1. Child follows proximal point during book activity	
2. Child turns or switches gaze when adult points	

PLAY SESSIONS

RJA	**IJA**
A. Adult's behavior	**Child's behavior**
1. Adult uses verbal directives (may include showing or pointing)	1. Eye contact
2. Different initial adult/child focus	2. Alternating/referencing
3. Adult intends to shift the child's gaze	3. Pointing+eye contact
	4. Showing+eye contact
	5. Using language to initiate
B. Child's behavior	
1. Child turns or switches gaze	

2. Language, eye contact, or pointing can be present

PA

A. Adult's behavior

1. Adult puts the object in front of the child, OR Adult puts child's hand on the object and helps him manipulate the object, OR Adult turns on an object which moves, gives out light or sound

2. Adult can use verbal directives

B. Child's behavior

1. Child shows no verbal behavior, eye contact, or pointing

2. Child can look at and/or play with the object

Table 3. The coding scheme for HSJE and LSJE adapted from Bottema-Beutel et al. (2014) comparing adult and child behaviors during a JA episode in ECSC vs. parent-child play sessions.

Engagement State	**Definition**	**Examples and Non-Examples**
Supported joint engagement (SJE)	The parent and child are engaged with the same materials. The parent's actions influence the child's play, but the child does not visually reference the adult's face.	Examples: a) the parent and child face a puzzle on the floor, and take turns putting pieces together; b) the parent demonstrates the way a toy works and then the child immediately imitates her action on the object. Non-Examples: a) the parent and child face a puzzle on the floor, taking turns putting the pieces together. Each time the child puts a piece down, he looks up and smiles at the parent. This would be Joint Attention; b) the child sits in the mom's lap while the mom reads but the child is looking at the buckets across the room. This would be Passive Attention.
Higher order supported joint engagement (HSJE)	Within an SJE framework, the child reciprocates the adult's actions or collaborates with the adult. This includes turn taking sequences, imitation sequences, the child following through on the verbal commands of the parent, and heightened affective displays if the parent performs an action explicitly meant to elicit affect from the child.	Examples: a) Child attempts to open jar and reaches for adult hand to request help. The adult helps child open jar and child continues engagement with the jar/its contents, occasionally sharing it with the adult; b) The parent demonstrates an action on a toy and the child physically prompts a repetition or modification of that action. Non-Examples: a) The child touches the beads in the adult's hand as the adult puts it on his/her head; the adult continues this action and the child neither protests nor shows evidence of approval. This would be low SJE; b) The adult puts beads on the child's head and the child

Engagement State	Definition	Examples and Non-Examples
		removes them (only two turns occur)—all without the child referencing the adult. This would be low SJE.
Lower order supported joint engagement (LSJE)	Within an SJE framework, there are no reciprocal or collaborative exchanges between the dyad	Examples: a) The child touches the beads in the adult's hand as the adult puts it on his/her head; the adult continues this action and the child neither protests nor shows evidence of approval; b) The adult puts beads on the child's head and the child removes them (only two turns occur)—all without the child referencing the adult. Non-Examples: a) Child watches adult stack buckets and does not engage with buckets. This would not be coded; b) The child and the adult are playing with the beads and the child directs his/her own attention to the rattle without referencing the adult. The adult continues to play with and/or comment upon the beads. This would not be coded.

Table 4. Spontaneous language (Following-In) Variables

Maternal Utterances	**Episode Type**
Follow-In Comments	During Response to Joint Attention
	During Initiation of Joint Attention
	During Mutual Joint Attention
	During Passive Attention
	During High-Supported Joint Engagement
	During Low-Supported Joint Engagement
Follow-In Directives for Behavior	During Response to Joint Attention
	During Initiation of Joint Attention
	During Mutual Joint Attention
	During Passive Attention
	During High-Supported Joint Engagement
	During Low-Supported Joint Engagement
Follow-In Directives for Communication	During Response to Joint Attention
	During Initiation of Joint Attention
	During Mutual Joint Attention
	During Passive Attention
	During High-Supported Joint Engagement
	During Low-Supported Joint Engagement

Table 5. *M* and *SD* of scores on standardized tests of groups.

	TD		**High-Verbal ASD**		**Low-Verbal ASD**	
	Mean	**(SD)**	**Mean**	**(SD)**	**Mean**	**(SD)**
Age	20.3	(1.63)	34.34	(6.46)	32.13	(8.15)
CDI	316.97	(159.6)	317.19	(167.03)	121	(109.66)
ADOS[1]	0.85	(1.52)	11.88	(3.10)	16.33	(3.64)
Vineland Communication[2]	104.97	(8.81)	86.63	(13.97)	64.4	(11.40)
Vineland Daily Living Skills	104.45	(8.73)	83.44	(13.88)	72.2	(11.75)
Vineland Social	101.03	(6.70)	75.69	(7.69)	71.27	(7.17)
Vineland Motor	100.21	(6.83)	88.19	(11.81)	80.8	(13.82)
Mullen Visual[3]						
RAW scores	26.09	(3.32)	29.5	(7.56)	26	(2.55)
t scores[3]	58.70	(9.95)	44.56	(12.35)	30.13	(13.94)
Mullen Fine Motor						
RAW scores	22.73	(2.58)	27.5	(5.24)	23.67	(2.18)
t scores[3]	50.63	(8.81)	44.56	(12.35)	30.13	(13.94)
Mullen Receptive Language						
RAW scores	24.36	(3.47)	26.17	(9.87)	14.78	(7.63)
t scores[3]	58.12	(11.52)	44.56	(12.35)	30.13	(13.94)
Mullen Expressive Language						
RAW scores	20.10	(5.09)	22.5	(5.89)	12.44	(2.30)

t scores[3]	50.15 (12.88)	44.56 (12.35)	30.13 (13.94)

[1] Cut-off score for a diagnosis of autism is 12, and cut-off score for a diagnosis of autism spectrum disorders is 7.

[2] Vineland scores represent standard scores: $M = 100$, $SD = 15$.

[3] t scores: $M = 50$, $SD = 10$.

Table 6. Means and SDs of joint attention and supported joint engagement time measures (seconds), and ANOVA results for across-groups

	Mean(SD)						
	High-Verbal (HV) ASD	**Low-Verbal (LV) ASD**	**TD**	**F**	**df**	***p***	**Pairwise comparisons**
RJA	861.25 (374.94)	382.13 (339.90)	966.86 (258.54)	18.71	(2,61)	< 0.01**	LV ASD < HV ASD** TD > LV ASD**
IJA	65.62 (57.23)	13.36 (26.59)	121.68 (91.64)	11.81	(2,61)	< 0.01**	TD > HV ASD* TD > LV ASD**
MJA	189.27 (224.86)	279.43 (257.88)	249.96 (267.05)	0.52	(2,61)	0.598	
PA	201.20 (238.00)	462.88 (344.37)	131.17 (126.53)	11.59	(2,61)	< 0.01**	LV ASD > HV ASD** TD < LV ASD**
HSJE	161.16 (285.15)	205.17 (334.22)	222.50 (288.56)	0.23	(2,61)	0.797	
LSJE	95.24 (152.45)	162.46 (169.09)	29.93 (55.73)	6.76	(2,61)	0.002*	LV ASD = HV ASD TD = HV ASD TD < LV ASD**

Table 7. Means and SDs of joint attention and supported joint engagement count measures (number of episodes), and ANOVA results for across-groups

	Mean(SD)						
	High-Verbal (HV) ASD	**Low-Verbal (LV) ASD**	**TD**	**F**	**df**	***p***	**Pairwise comparisons**
RJA	13.48 (5.21)	8.16 (7.16)	16.29 (4.20)	12.34	(2,61)	< 0.01**	LV ASD < HV ASD* TD > LV ASD**
IJA	1.92 (1.98)	0.40 (0.68)	3.43 (2.75)	9.81	(2,61)	< 0.01**	TD > LV ASD**
MJA	4.19 (4.97)	5.82 (5.23)	5.98 (6.56)	0.53	(2,61)	0.593	
PA	5.42 (4.43)	13.29 (7.57)	4.18 (2.99)	19.57	(2,61)	< 0.01**	LV ASD > HV ASD** TD < LV ASD**
HSJE	3.35 (5.19)	3.73 (5.28)	5.51 (6.39)	0.92	(2,61)	0.406	
LSJE	2.69 (2.71)	10.55 (23.41)	1.40 (2.12)	3.44	(2,61)	0.04*	TD < LV ASD*

Table 8. Means and SDs for percentage of utterance types in the TD and ASD groups, and ANOVA results for across-groups

	Mean(SD)						
	High-Verbal (HV) ASD	**Low-Verbal (LV) ASD**	**TD**	**F**	**df**	***p***	**Pairwise comparisons**
FIC	35.30 (9.25)	33.68 (11.73)	39.96 (8.31)	2.78	(2,61)	0.07	
FIDB	22.04 (6.34)	20.16 (8.65)	21.64 (5.93)	0.35	(2,61)	0.71	
FIDC	19.46 (5.65)	13.97 (8.26)	20.76 (3.83)	7.74	(2,61)	< 0.01**	LV ASD < HV ASD* TD > LV ASD**
Others	23.20 (11.99)	32.18 (19.41)	17.63 (7.85)	7.12	(2,61)	< 0.01**	TD < LV ASD**

Table 9. Means and SDs for number of utterance types in the TD and ASD groups, and ANOVA results for within-subjects comparisons

	Mean(SD)						
TD							
	FIC	**FIDB**	**FIDC**	**F**	**df**	***p***	**Pairwise comparisons**
RJA	409.09 (189.48)	213.24 (80.29)	208.06 (84.37)	26.28	(2,33)	< 0.01**	FIC > FIDB** FIC > FIDC**
IJA	55.06 (47.37)	17.53 (13.68)	25.56 (22.03)	12.86	(2,32)	< 0.01**	FIC > FIDB** FIC > FIDC**
MJA	84.16 (83.46)	37.12 (36.30)	46.16 (47.48)	4.44	(2,25)	0.0153*	FIC > FIDB**
PA	39.81 (33.86)	40.00 (40.44)	24.00 (22.06)	2.40	(2,31)	0.0966	
HSJE	49.00 (44.18)	23.00 (21.16)	27.09 (26.78)	4.33	(2,21)	0.0171*	FIC > FIDB**
LSJE	9.76 (11.29)	6.47 (9.79)	6.76 (7.47)	0.61	(2,17)	0.549	FIC > FIDC**
ASD							
	FIC	**FIDB**	**FIDC**	**F**	**df**	***p***	**Pairwise comparisons**
RJA	304.83 (207.59)	174.14 (135.91)	165.03 (127.57)	6.84	(2,29)	0.00177**	FIC > FIDB** FIC > FIDC**
IJA	25.89 (20.85)	10.63 (9.42)	10.32 (9.53)	7.36	(2,19)	0.00149**	FIC > FIDB** FIC > FIDC**
MJA	65.69 (72.89)	30.15 (27.84)	29.38 (32.15)	4.71	(2,26)	0.0118*	FIC > FIDB* FIC > FIDC*
PA	118.48 (125.35)	100.61 (109.23)	57.42 (59.76)	2.94	(2,31)	0.0582†	FIC > FIDC†
HSJE	61.50 (76.96)	25.32 (48.57)	23.18 (33.70)	3.25	(2,22)	0.0454*	
LSJE	28.45 (32.64)	20.07 (28.24)	9.14 (12.17)	4.06	(2,29)	0.0208*	FIC > FIDC**

Table 10. TD and ASD percentages of utterances across all episode types

	Mean(SD)							
	FIC	**FIDB**	**FIDC**	**Others**	**F**	**df**	***p***	**Pairwise comparisons**
TD	39.96 (8.31)	21.64 (5.93)	20.76 (3.83)	17.63 (7.85)	74.89	(3,33)	< 0.01**	FIC > FIDB** FIC > FIDC** FIC > Others**
ASD	34.51 (10.38)	21.13 (7.48)	16.81 (7.46)	27.55 (16.39)	15.18	(3,31)	< 0.01**	FIC > FIDB** FIC > FIDC** FIDC > Others**

Table 11. ANOVA TD and ASD percentages of all utterance types combined in each episode type

	Mean(SD)										
	RJA	**IJA**	**MJA**	**PA**	**HSJE**	**LSJE**	**Others**	**F**	**df**	***p***	**Pairwise comparisons**
TD	55.89 (13.77)	6.39 (5.13)	7.83 (8.58)	7.02 (6.87)	4.88 (6.30)	0.77 (1.34)	17.22 (7.93)	189.2	(6,33)	< 0.01**	IJA < Others** IJA < RJA** MJA < LSJE** MJA < Others** MJA > RJA** PA < RJA** HSJE > Others** HSJE < RJA** LSJE < Others** LSJE < PA* LSJE < RJA** Others > PA** Others < RJA**
ASD	37.42 (24.77)	2.04 (2.63)	6.80 (7.90)	18.34 (18.78)	4.23 (6.63)	3.61 (4.47)	27.55 (16.39)	30.36	(6,31)	< 0.01**	IJA < Others** IJA < RJA** MJA > LSJE** MJA < Others** MJA < PA† MJA < RJA** PA < RJA** HSJE < Others** HSJE < PA** HSJE < RJA** LSJE < Others** LSJE < PA* LSJE < RJA** Others < RJA**

Table 12. Significant correlations from the correlation matrix for caregiver input variables with child language outcome variables in the TD group, using the raw data, and including *p* values (N = 33).

	Noun tokens V6	**Noun types V6**	**Verb tokens V6**	**Verb types V6**	**MLU V6**	**Mullen Expressive language V6**	**Shape Bias V4**	**Mullen Receptive language V6**
Average IJA time	0.113	0.233	0.097	0.085	-0.079	**0.527****	0.220	**0.385***
Average RJA time	-0.070	0.022	0.247	0.097	0.091	-0.132	-0.120	0.031
Average MJA time	-0.094	-0.168	-0.327	-0.265	-0.251	0.110	0.033	0.218
Average PA time	0.215	0.042	0.129	0.235	0.138	-0.187	0.102	**-0.355***
Average HSJE time	-0.276	-0.299	**-0.420***	**-0.422***	**-0.388***	-0.086	-0.091	0.103
Average LSJE time	-0.254	-0.314	-0.326	-0.254	0.202	-0.040	-0.014	-0.145
Average utterances FIC	0.025	0.081	0.112	-0.003	0.010	**0.366***	-0.079	0.116
Average utterances FIDB	0.142	-0.030	0.236	0.221	0.325	0.305	-0.026	-0.242
Average utterances FIDC	-0.080	-0.090	-0.064	-0.149	-0.084	**0.413***	-0.117	0.050
Average utterances that are not FI	-0.012	-0.035	0.074	0.050	0.133	0.016	-0.200	**-0.354***
IJA overall FI utterances percentage	0.213	**0.348***	0.100	0.111	-0.093	**0.497***	0.258	**0.407***
RJA overall FI utterances percentage	-0.049	0.047	0.256	0.114	0.152	-0.125	-0.127	0.026

	Noun tokens V6	**Noun types V6**	**Verb tokens V6**	**Verb types V6**	**MLU V6**	**Mullen Expressive language V6**	**Shape Bias V4**	**Mullen Receptive language V6**
MJA overall FI utterances percentage	-0.026	-0.127	-0.232	-0.141	-0.182	0.191	0.033	0.225
PA overall FI utterances percentage	0.274	0.089	0.130	0.247	0.167	-0.150	0.131	**-0.358***
HSJE overall FI utterances percentage	-0.266	-0.235	**-0.412***	**-0.417***	**-0.357***	-0.098	0.002	0.140
LSJE overall FI utterances percentage	-0.322	**-0.366***	**-0.380***	-0.311	0.176	-0.016	-0.016	-0.126
Overall FI utterances percentage that are not in any episode type	0.004	0.003	0.021	-0.017	0.102	-0.099	-0.096	-0.324

Table 13. Significant correlations from the correlation matrix for caregiver input variables with child language outcome variables in the ASD group, using the raw data, and including *p* values (N = 31).

	Noun tokens V6	**Noun types V6**	**Verb tokens V6**	**Verb types V6**	**MLU V6**	**Mullen Expressive language V6**	**Shape Bias V4**	**Mullen Receptive language V6**
Average IJA time	**0.575****	**0.530****	**0.502****	**0.520****	**0.579****	**0.562****	**0.408***	**0.591****
Average RJA time	**0.674****	**0.6718****	**0.726****	**0.731****	**0.719****	**0.716****	0.230	**0.740****
Average MJA time	0.012	0.033	-0.091	-0.106	0.092	0.161	0.169	0.206
Average PA time	**-0.557****	**-0.533****	**-0.584****	**-0.571****	**-0.632****	**-0.662****	**-0.439***	**-0.603****
Average HSJE time	0.198	0.193	0.067	0.044	0.090	0.158	0.130	0.293
Average LSJE time	-0.272	-0.251	-0.330	-0.337	-0.222	-0.214	0.112	**-0.354†**
Average utterances FIC	0.217	0.238	0.198	0.199	0.304	0.339	0.104	**0.442***
Average utterances FIDB	0.013	0.054	-0.009	-0.014	0.024	0.029	-0.168	0.143
Average utterances FIDC	**0.498****	**0.543****	0.305	0.342	0.342	**0.445***	-0.036	**0.434***
Average utterances that are not FI	**-0.397***	**-0.426***	**-0.453***	**-0.445***	**-0.553***	**-0.494***	-0.112	**-0.590****
IJA overall FI utterances percentage	**0.617****	**0.597****	**0.494****	**0.510***	**0.554***	**0.547***	0.332	**0.605****
RJA overall FI utterances percentage	**0.644****	**0.651****	**0.709****	**0.717****	**0.717****	**0.708****	0.236	**0.726****

	Noun tokens V6	**Noun types V6**	**Verb tokens V6**	**Verb types V6**	**MLU V6**	**Mullen Expressive language V6**	**Shape Bias V4**	**Mullen Receptive language V6**
MJA overall FI utterances percentage	0.021	0.048	0.007	-0.004	0.238	0.290	0.110	0.286
PA overall FI utterances percentage	**-0.585****	**-0.567***	**-0.596****	**-0.594****	**-0.648****	**-0.679****	**-0.472***	**-0.630****
HSJE overall FI utterances percentage	0.206	0.201	0.097	0.063	0.125	0.190	0.140	0.301
LSJE overall FI utterances percentage	**-0.352†**	-0.333	**-0.387***	**-0.392***	-0.258	-0.268	0.088	**-0.390***
Overall FI utterances percentage that are not in any episode type	**-0.405****	**-0.450***	**-0.413***	**-0.409***	**-0.531****	**-0.523***	-0.076	**-0.627****

Table 14. Means and SDs of the outcome measures at visit 6 (and SB at visit 4) in all three groups.

Outcome measures	**High-Verbal (HV) ASD**	**Low-Verbal (LV) ASD**	**TD**
Noun types V6	38.13 (19.09)	10.86 (14.76)	39.72 (14.97)
Noun tokens V6	82.5 (45.18)	20.29 (30.15)	82.12 (37.70)
Verb types V6	43.13 (26.26)	6.64 (10.99)	44.67 (13.46)
Verb tokens V6	149.06 (103.99)	23.07 (45.72)	158.73 (71.69)
MLU V6	2.64 (0.76)	1.27 (0.68)	2.94 (0.52)
Mullen Expressive Language V6	36.63 (9.29)	19 (11.03)	40.47 (4.61)
Shape Bias at V4	0.05 (0.12)	-0.02 (0.09)	0.07 (0.12)
Mullen Receptive Language V6	37.31 (9.41)	26.73 (9.09)	39.53 (4.30)

Table 15. Summary of the significant and near-significant hierarchical regression analyses for variables predicting TD group's receptive and expressive language scores at visit 6 (N = 33).

Final model:	***B***	***SE(B)***	***β***	**ΔR^2**
(a) Predicting Mullen Expressive Language V6				
Mullen Visual Reception V1	0.2729	0.2524	0.1985099	
Mullen Expressive Language V1	0.1632	0.1620	0.1827993	
% of overall maternal FI utterances during IJA	0.3753	0.1427	0.4136583	0.1601*

Table 16. Summary of the significant and near-significant hierarchical regression analyses for variables predicting ASD group's receptive and expressive language scores at visit 6 (N = 31).

Final model:	***B***	***SE(B)***	***β***	**ΔR^2**
(a) Predicting Total nouns tokens V6				
Mullen Visual Reception V1	-0.5684	1.4162	-0.0655572	
Total child noun tokens V1	0.5468	0.1886	0.4161716	
% of overall maternal FI utterances during IJA	10.9933	7.7761	0.5906338	0.1244**
Average maternal utterances that are FIDC	0.4814	0.1284	0.4903865	0.1443**
(b) Predicting Total nouns types V6				
Mullen Visual Reception V1	-0.3919	0.54706	-0.1025951	
Total child noun types V1	0.64108	0.18628	0.4309340	
% of overall maternal FI utterances during IJA	7.80820	3.09878	0.9520845	0.1157**
Average maternal utterances that are FIDC	0.21619	0.04963	0.4997753	0.1698**
(c) Predicting Total verbs tokens V6				
Mullen Visual Reception V1	0.9877	2.3975	0.05483317	
Total child verb tokens V1	1.5047	0.3149	0.51682998	
IJA time	1.3628	0.7658	0.69101087	0.0621**
RJA time	0.3507	0.2319	1.47705833	0.0445*
(d) Predicting Total verbs types V6				
Mullen Visual Reception V1	0.47865	0.69340	0.09975357	
Total child verb types V1	1.46243	0.38081	0.47502450	
IJA time	0.29005	0.21764	0.55209924	0.0992**
(e) Predicting MLU V6				
Mullen Visual Reception V1	0.00921	0.0217	0.05308906	
Child MLU V1	0.65334	0.1467	0.44042659	
% of overall maternal FI utterances during RJA	0.01599	0.0048	0.40592570	0.1076**
IJA time	0.00579	0.0017	0.30474834	0.0804**
(f) Predicting Mullen Expressive Language V6				
Mullen Visual Reception V1	0.58914	0.37301	0.24801357	
Mullen Expressive Language V1	0.92223	0.33940	0.50388194	
% of overall maternal FI utterances during MJA	0.88036	0.36505	0.51793257	0.1009**
(g) Predicting Mullen Receptive Language V6				
Mullen Visual Reception V1	0.63082	0.3003	0.33720922	
Mullen Receptive Language V1	0.45047	0.2103	0.39555877	
% of overall maternal FI utterances during IJA	2.15792	1.6534	0.53766355	0.0648**

Table 17. Summary of the significant and near-significant hierarchical regression analyses for variables predicting Higher-Verbal ASD group's receptive and expressive language scores at visit 6 (N = 16).

Final model:	***B***	***SE(B)***	***β***	**ΔR^2**
(a) Predicting MLU V6				
Mullen Visual Reception V1	0.016464	0.023227	0.1139127	
Child MLU V1	0.598976	0.164265	0.5724272	
Average maternal utterances that are Others	-0.007291	0.002544	-0.4352766	0.1614*

Table 18. Summary of the significant and near-significant hierarchical regression analyses for variables predicting Lower-Verbal ASD group's receptive and expressive language scores at visit 6, and shape bias at visit 4 (N = 15).

Final model:	***B***	***SE(B)***	***β***	**ΔR^2**
(a) Predicting Total nouns tokens V6				
Mullen Visual Reception V1	-0.1727	1.5294	-0.02685386	
Total child noun tokens V1	7.8739	4.6158	0.37581375	
% of overall FI utterances that are in IJA	15.2200	4.9850	0.67037956	0.3796*
(b) Predicting Total verbs tokens V6				
Mullen Visual Reception V1	-1.9921	1.6815	-0.2042620	
Total child verb tokens V1	1.4530	0.9119	0.2745097	
IJA time	1.0538	0.3806	0.6354375	0.6520**
(c) Predicting Total verbs types V6				
Mullen Visual Reception V1	-0.0592	0.4014	-0.02526187	
Total child verb types V1	3.9466	2.5575	0.32827726	
IJA time	0.8897	0.2560	2.23255233	0.6728**
(d) Predicting MLU V6				
Mullen Visual Reception V1	0.014353	0.049948	0.09875687	
Child MLU V1	0.386738	0.711273	0.17731947	
% of overall FI utterances that are in MJA	0.047948	0.036643	0.55758977	0.4630**
(e) Predicting Mullen Expressive Language V6				
Mullen Visual Reception V1	-0.18214	0.39912	-0.07458634	
Mullen Expressive Language V1	1.79358	0.83912	0.35227269	
% of overall FI utterances that are in MJA	0.62378	0.29466	0.44146530	0.3253**
(f) Predicting Mullen Receptive Language V6				
Mullen Visual Reception V1	0.411787	0.471977	0.2046437	

Final model:	***B***	***SE(B)***	***β***	**ΔR^2**
Mullen Receptive Language V1	0.300109	0.314832	0.2029200	
IJA time	0.177670	0.221020	0.5197088	0.1905**
(g) Predicting Shape Bias V4				
Mullen Visual Reception V1	-0.004219	0.003667	-0.2176998	
Mullen Receptive Language V1	-0.003629	0.002483	-0.2461355	
% of overall FI utterances that are PA	-0.002821	0.000909	-0.5994704	0.5483**
% of overall FI utterances that are IJA	0.034130	0.012857	0.5034983	0.1668*