Relationship Between Young Children's Gestures and Language Development

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THESIS

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This thesis is dedicated to my Godchildren, Caitlin and Michael John. Caitlin taught me many lessons about living, and Michael John continues to teach me about language. This is also dedicated to my parents, who have encouraged me in all my academic endeavors.

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LIST OF ABBREVIATIONS

ADOS	Autism Diagnostic Observation Scale
ANOVA	Analysis of Variance
ANCOVA	Analysis of co-variance
ASD	Autism spectrum disorder
BS	Behavior Sample
CARS	Childhood Autism Rating Scale
CELF	Clinical Evaluation of Language Fundamentals
CQ	Caregiver Questionnaire
CSBS DP	Communication Symbolic Behavior Scales Developmental Profile
DP	Developmental Profile
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders, fourth edition
EFA	Exploratory factor analysis
ELI	Early Language Inventory
EOWPVT	Expressive One Word Picture Vocabulary Tests
ESCS	Early Social Communication Scale
GRF	Gestural Recording Form
HLM	Hierarchical linear modeling
IDEA	Individuals with Disability Education Act
ITC	Infant-Toddler checklist
KMO	Kaiser-Meyer-Olkin
LGI	Language and Gesture Inventory
MANOVA	Multivariate Analysis of Variance

LIST OF ABBREVIATIONS (continued)

MBCDI	MacArthur-Bates Communicative Development Inventory
M-CHAT	Modified Checklist of Autism in Toddlers
MLU	Mean length of utterance
PCA	Principal Component Analysis
PPVT-III	Peabody Picture Vocabulary Test-III
ROWPVT	Receptive One Word Picture Vocabulary Test
SALT	Systematic Analysis of Language Transcripts
SES	Socioeconomic status
SICD	Sequenced Inventory of Communicative Development
SLI	Specific language impairment
SLPs	Speech-language pathologists
ST	Sign training
TD	Typically developing
VIF	Variance inflation factor
WG	Words and Gestures

SUMMARY

This study extended research on relationships among gesture and language development in young children, through the design and evaluation of a parent report measure of early gesture use. Using factor analysis, Rasch analysis, and regression analyses, the study assessed relationships among gesture use, sociocultural variables, risk for autism, and language development in young children, using a newly devised parent report instrument, the *Checklist of Children's Gestures* (Brann, 2009). Parents completed the *Checklist of Children's Gestures* for their two- or three-year-old children (n = 179). Factor analysis confirmed previous research on the functions of children's gesture use. Rasch analysis revealed the developmental pattern of gesture use. Regression analyses indicated age and socioeconomic differences on gesture ability. Most important, gesture ability explained a significant amount of variance on the language scores on the *Bayley Scales of Infant and Toddler Development,* even after controlling for sociocultural measures (child's age, gender, SES, ethnicity, and language learning environment), and autism screening status on the *M-CHAT*. As the goal of early language assessment is to evaluate the strengths and needs of communicative interactions and pre-speech language functioning in infants and toddlers, these findings suggest that speech language pathologists and early intervention providers may find it valuable to use a reliable, valid, and feasible parent checklist to assess children's gestures and to target gestures in language intervention.

I. INTRODUCTION

The Problem and its Significance

As sociocultural theories about children's language development have become more prevalent, research on oral language acquisition has broadened from the study of syntax and semantics to include social aspects of language use. This change has been especially apparent in the study of early language development, since researchers have identified social precursors of the use of first words. In particular, there has been a recent explosion of research on gesture and its relationship to the comprehension and production of oral language. The research suggests that gestures have great potential for assessment and intervention for infants and toddlers at risk for language disability. However, in spite of this research, the relationships among gesture use, sociocultural measures and language are still not well understood. The findings and interpretations of these studies are difficult to interpret due to varying definitions of gestures, conflicting coding schemes, different procedures and study designs.

Definition and Functions of Gestures in Early Development

Nonverbal communication may convey more information than the spoken word, and words may be a less important mode of communication (Mehrabian, 2009). Therefore, gestures may be as important as words in assessing children's language skills.

Gestures have been defined as bodily movements made with arms, hands, legs, or head that are expressive of thought or feelings (Kendon, 2003; McNeill, 2005). Gestures are almost always made with communicative intent (Goldin-Meadow, 2005). Researchers use many overlapping and different systems for categorizing the same gestures, e.g., conventional gestures, representational gestures, or symbolic gestures. However, McNeill's (2005) classification system, used most often in recent literature, was used in the present study since it is the clearest

system. McNeill classified gestures as deictic and iconic. Deictics are pointing gestures, which most researchers agree develop between 9 to 12 months of age (Bates & Dick, 2002; Thal & Bates, 1988). There are several types of pointing gestures: pointing to obtain an object, or pointing to share interest or attention about the world. A third type of pointing, referential pointing, is similar to non-verbal naming (Goodhart & Baron-Cohen, 1993).

Iconic gestures are gestures in which the hands and the speech express the same concept at the same time. One example of an iconic gesture is a speaker running his fingers through his hair while saying "combing". This typically begins to occur at approximately 12 months of age (Bates, Thal, Fenson, Whitesell, & Oakes, 1989). McNeill's other types of gestures (beats and metaphoric gestures) will not be discussed here since they occur in older children and adults and the focus of this study is on children in the first three years of age.

Gestures are symbols that may serve the same function as words (Fenson, Dale, Reznick, Bates, Pethick, 2004) and may have preceded speech in evolution (Corballis, 2002). There is evidence that hominids gestured to communicate before they produced words (Bohannon & Bonvillain, 1993). In children, gesture's role is varied. For example, gestures may be precursors of the child's first words (Fenson et al., 2004) and may also be a signal that the child is moving to the two-word stage of language development (Iverson & Goldin-Meadow, 2005).

Gestures are one early indicator of children's intentionality (Crais, Douglas, & Campbell, 2004; Goldin-Meadow, 2003). There are two levels of intentionality inherent in every pointing gesture: first, the parents must know exactly *what* their child is pointing to; second, the parents must know *why* the child is pointing. Both intentions depend on establishing common ground between the parent and child (Tomasello, Carpenter, & Liskowski, 2007). Therefore, the interpretation of a pointing gesture depends on the shared experience between the child and his

or her parents. Infants may use the pointing gesture non-socially initially, but, through interaction with their parents, it became social.

Gestures used by infants and toddlers are prelinguistic skills that meet Bruner's (1983) three categories of communicative function: to regulate behavior (by requesting objects or actions or protesting); to establish joint attention (by commenting and requesting information), and to initiate social interaction (by using representational gestures, attention seeking, and social games). Crais et al. (2004) showed that behavior regulation gestures were the first gestures to emerge, followed by social interaction gestures.

Of the three types of Bruner's communicative functions, joint attention may be the best predictor of concurrent language ability. Lock and Zukow-Goldring (2010) viewed joint attention as an interactive activity, in which the child and the parent simultaneously coordinate their attention on a common focus. This shared attention, critical to most social and language development, begins early. By 12 months, most infants display joint attention behaviors, including sharing eye gaze, following a pointing gesture, and following or directing the attention of another (Dawson et al., 2004).

When the infant is approximately nine months old, communication skills develop further as the child begins to use proto imperative gestures (requests for an object by reaching or pointing to it), and proto declarative gestures (child points to something of interest in order to share attention with an adult) (Lock & Zukow-Goldring, 2010). At 12 months of age, most infants move further into the language domain in both the gesture and language modalities. Gestures predominate until about 16 months of age, when words become more prevalent (Iverson & Goldin-Meadow, 2005). When the infant is between 17 and 18 months of age, the child's gestures begin to co-occur with words.

During the second year of a child's life, gesture plus word combinations precede two-word phrase productions, and the gesture modality becomes elaborated before the verbal modality. The child typically combines two words by the end of second year, and, at the same time, uses gestures less frequently. Gestures, however, do not disappear entirely, but instead take on a new role to express information that is not stated in the child's words.

Gestures as Diagnostic Tool

A growing body of research suggests that not only are gestures good predictors of later developmental or language disorders, but also that interventions that target gesture use can enhance oral language development. Both the quantity (e.g., Thal & Tobias, 1991) and the type of gestures (e.g., Goodhart & Baron-Cohen, 1993) may have diagnostic value. Specifically, the absence of giving, pointing, and waving may be a predictor of autism and is a diagnostic criterion in the DSM-4. Additionally, the absence of protodeclarative gesture in young children may be related to impairments of autism (Goodhart & Baron-Cohen, 1993). The results of Thal and Tobias' (1991) study showed that children who were truly late talkers performed significantly lower on all gesture tasks than children who were late bloomers, i.e., who eventually caught up with their peers' language development.

In a rare experimental study, Goodwyn, Acredolo, and Brown (2000) trained parents to gesture to their child, and those children scored higher than a control group on receptive and expressive language scores. One explanation is that parents gesture and produce words with equal frequency in joint attention interactions, which may account for young children's acquisition of both verbal and gestural communication (Namy, Acredolo, & Goodwyn, 2000). Taken together, these results indicate that children's gesture use should be assessed in clinical evaluations, on populations of children with language disabilities and autism.

Demographic Variables and Gestures

Findings that the type of gesture or the quantity of gestures that a child uses may have diagnostic value validate the need to clarify the relationships among gesture uses, sociocultural measures, and language. For example, Rowe, Ozcaliskan, and Goldin-Meadow (2008) found differences in gesture use in children from different social classes: parents and children from higher SES homes used more gestures than low income parents and children, and children's gesture use was correlated with receptive vocabulary at 54 months on the *Peabody Picture Vocabulary Test* (PPVT). However, earlier tests of gestures did not include children from lower SES groups, thereby possibly biasing the results. Studies of gesture tests with varied socioeconomic groups is needed.

Variation in Methods for Measuring Gesture Use

The results of these studies are difficult to interpret and apply to clinical language assessment, due to various methodology issues. First, the most crucial issue is that what constitutes a gesture varies from one study to the next. Consequently, gestures are coded differently in each study. For example, some studies coded only empty-handed gestures (Namy, Acredolo & Goodwyn, 2000; Olson & Mazur, 2011; Rowe, Raudenbush, & Goldin-Meadow, 2012). One study excluded the pointing gesture completely (Namy et al., 2000) while another study divided the pointing gesture into three different types: protodeclarative, proto imperative, and referential (Goodhart & Baron- Cohen, 1993). In addition, several studies excluded conventionally acquired gestures such as *yes* and *no* in an effort to target specific gestures during the study (Goodwyn, Acredolo, & Brown, 2000). Although the focus of those studies differed from the purpose of clinical use, uniform definitions and coding schemes for gestures are needed.

Similarly, Clark and Estigarriba's (2011) study showed another variation in the taxonomy of gestures. Gestures were classified as indicating and demonstrating, neither of which are terms typically seen in the gesture literature. In addition to differences in coding schemes, Crais et al. (2004) counted gestures only when they were directed towards an adult, but did not, however, require the child to use eye gaze.

Additionally, there is considerable variation in methods used to measure gesture. Most research studies have videotaped parent and child interactions, and later analyzed the gestures in a research lab (Olson & Mazur, 2011; Iverson & Goldin-Meadow, 2005; Namy, Acredolo & Goodwyn, 2000). Interestingly, some of the free play studies have selected toys specifically for the study in order to elicit specific gestures (Clark & Estigarriba, 2011; Namy et al., 2000). In contrast, de Villers Radar and Zukow-Goldring's (2010) study used novel toys, and furthermore, invented nonsense names for the novel toys for their study. Goodhart and Baron-Cohen (1993) analyzed gestures the children and parents produced in a two minute pointing to picture book task, a situation that did not elicit many gestures.

Parent Report in the Assessment of Young Children

Several issues arise in the assessment of young children's language skills. First, they are difficult to test due to stranger anxiety; second, the lack of naturalistic testing situations may affect the results of studies of gestures. While videotaping gesture use during parent-child interactions is typically used for research purposes, this approach would not be practical for clinical purposes. Many young children may not cooperate with formal testing (Voight et al., 2003). Similarly, behavioral observations of children under the age of three may not be representative of the child's true ability (Thal et al., 1995). An alternative is the use of parent

report, an approach that has been shown to be reliable and valid in the assessment of children's oral language development (Crais et al., 2004).

Some evidence suggests that parent report may also be a clinically useful approach for assessing gesture use. For example, Crais et al. (2004) used a parent report instrument, later confirming that the child used each gesture reported by the parents with in-home observation by the researcher.

Several standardized language tests include a parent report measure of a small range of gestures in their test items. For example, the *Communication Symbolic Behavior Scales Developmental Profile* (CSBS DP) (Wetherby & Prizant, 2002) has three components, one of which is a parent checklist that asks if their child uses a few gestures. The *MacArthur-Bates Communicative Development Inventory* (MBCDI) (1993) is a parent report instrument that included the Words and Gestures subtest. Another test of child language, the *Rossetti Infant Toddler Language Scale* (Rossetti, 1990), lists gesture as one of the six domains tested, but several of the items in this domain appear to assess play and self-care skills, rather than true gestures. In addition to the domain of gestures, both the receptive language and expressive language domains contain items about gestures.

In short, the clinician needs to search several sections of various test forms to identify which gestures a child does or does not currently use. The currently available tests that assess gestures have too few gesture items, or test items that mix up gestures and symbolic play. Taken together with the conflicting results of studies on gestures, it would appear that there is a need for a uniform, valid, and feasible means of assessing children's gestures, using the parent report format. Results of testing gestures may provide the clinician with helpful diagnostic information.

Gesture and Sociocultural Theory

Sociocultural theory has long been applied to child gesture and language development, since Vygotsky (1986) and Luria (1981) studied how language develops through social interaction between parent and the child. Vygotsky and Luria considered gestures, along with language and signs, to be psychological tools. Vygotsky described a child's pointing gesture as developing in a social context: first, the infant grasps his or her own hand, which the parent interprets as a pointing gesture, making the gesture now socially meaningful. This in turn may enable parents to 'fine-tune' their language and gestural input to the child, which may scaffold language acquisition (e.g., Goldin-Meadow, 2003).

The ways in which gesture use can aid children's language skills is derived from studies of parent-child interaction. For example, Clark and Estigarriba (2011) found that parents integrate gestures with their speech, and may possibly match their gestures to different verbal content. De Villiers Rader and Zukow-Goldring (2010) found that gestures that parents produce in synchrony with words may direct the infants' attention during word learning by the movement of the gesture timed in synchrony with parents' speech. Iverson and Goldin Meadow (2007) showed that the child was more likely to produce a word when the mother translated their gesture into words than when the mother did not translate the gestures into words. Other researchers have found mothers responded verbally to their child's gestures more often when children used the protodeclarative gesture (Olson & Mazur, 2011).

Purpose of the Study

Since the goal of assessment is to evaluate the strengths and weaknesses of early communicative interactions and pre-speech language functioning in infants and toddlers (asha.org), clinicians may find it valuable to assess children's gestures and to target gestures in

language intervention. Crais, Watson, Baranek, and Reznick (2006) recommend that speech-language pathologists (SLPs) create a comprehensive profile of children's gestures during a speech-language evaluation. However, to adequately assess children's gestures, a new instrument is needed. The purpose of this study was to address questions about the relationships among gesture uses, sociocultural variables, and language development in young children, using a newly devised instrument, the *Checklist of Children's Gestures* (Brann, 2009). This checklist assessed the gestures that young children use and imitate, using a parent report format. The hypotheses were that gestures would account for a significant amount of variance in language scores, and were related to demographic variables. One hundred and seventy-nine participants from an existing study at the University of Illinois at Chicago participated in this study. Parents completed the *Checklist of Children's Gestures* and the *Modified Checklist of Autism in Toddlers* at home. Children's language skills were assessed with the *Bayley Scales of Infant and Toddler Development* over two research sessions at the Brain-Body Center.

The present study was guided by four research questions:

1. What is the developmental pattern of gesture use in children with typical development?
2. What is the developmental pattern of gesture use in children who are at risk for autism?
3. What are the relationships among sociocultural measures of participants' gender, age, ethnicity, parental education level, socioeconomic status, and children's gesture ability?
4. Controlling for the sociocultural measures of participants' gender, age, ethnicity, parental education, socioeconomic status, and *M-CHAT* status, how much of the variance in the sum of language scaled scores on the *Bayley-III* can be explained by gesture ability?

II. LITERATURE REVIEW

As sociocultural theories about children's language development have become more prevalent, research on oral language acquisition has broadened from the study of syntax and semantics to include social aspects of language use. This change has been especially apparent in the study of early language development, as researchers have identified social precursors of the use of first words. In particular, there has been a recent explosion of research on gesture and its relationship to the comprehension and production of oral language. The research suggests that gestures have great potential for assessment and intervention for infants and toddlers at risk for language disability. However, in spite of this research, the relationships among gesture uses, sociocultural measures and language are still not well understood. The findings and interpretations of these studies are difficult to apply for clinical purposes, due to various definitions of gestures, conflicting coding schemes, different procedures and study designs. A standardized gesture coding scheme would aid in the clinical application of research findings.

Sociocultural Theory and Language

Vygotsky's theoretical work in the 1920s (1986) has been found to be especially useful for understanding the relations between gesture and language development. He considered language and nonverbal behavior to be socially meaningful activity, with the child's earliest speech already social during the first year of life. He viewed children's language development as a dynamic and changing process in several ways: first, language is the child's first way to interact with his or her environment by talking aloud during play; next, the child uses language to govern his or her actions or to direct thoughts. This reflects the changing role of language, from a social tool to a private tool. In agreement with the sociocultural theory, Bohannon and Bonvillian (1993) argue that the child and the environment are a dynamic system, each requiring

the other for efficient social communication e.g., the child cues his or her parents to supply an appropriate language experiences. Next, parents scaffold or support the young child's communication structure, allowing young child to communicate efficiently despite having a more primitive linguistic system than adult (Bruner, 1983). One example is child-directed speech, or 'motherese', which is argued to be finely tuned to the child's communication needs. Parents interpret their infant's babbling as meaningful, which in turn creates a reciprocal interaction that forms the framework for future language acquisition. It appears that the underlying structure of language is mapped and negotiated through this parent-child social interaction. The development of gesture appears to mirror and perhaps even precede this process.

Since humans are social organisms, it would be surprising if no relation existed between language and social skills in language acquisition (Bates, Thal, Fenson, Whitesell, & Oakes, 1983). Gestures may also facilitate language development in young children in social interaction with the parent. Gestures are expressions of thought (McNeill, 2005) in which the speaker embodies his or her thoughts by making an action. Therefore gestures reveal aspects of thought which may not be conveyed in spoken language. McNeill argues that speech and gesture are synchronous, and simultaneous. This same phenomenon may exist in parents' and children's gestures, with gestures possibly aiding a child's language development.

Sociocultural Theory and Children's Gestures

Sociocultural theories will frame this review of gesture's role in child language development for three reasons. First, Vygotsky (1986) and Luria (1981) may be the earliest language theorists who discussed gesture in their writings. Vygotsky and Luria considered gestures, along with language and signs, to be psychological tools. Vygotsky described a child's

pointing gesture as developing in a social context: first, the infant grasps his or her own hand, which the parents interpret as a pointing gesture; the gesture then becomes socially meaningful.

Luria, a student of Vygotsky who later paved the way for neuropsychologists, believes that the child is linked to his or her mother first physically as an infant, then emotionally, and later through speech. Through the mother, the child acquires new modes of behavior and new ways of organizing his/her mental activities. In regards to language, the mother names and points to objects in the environment and gives verbal instructions to the child, all of which shapes his or her behavior. According to Luria, the mother shows the child an object and points and names it, and next, the child observes his/her mother pointing, and soon begins to use his/her own finger to point.

The second reason that the sociocultural framework will be used to explore the gesture-language relationship is because many researchers appear to see the same social interaction in gestures as seen in language development. A number of studies use Vygotsky's scaffolding model to examine the role of parent-infant gesture and its link with language development (e.g., Goodwyn, Acredolo, & Brown, 2000; Namy, Acredolo, & Goodwyn, 2000; Zukow-Goldring, 2010). Another reason to view the gesture-language relationship through the sociocultural theory lens is that gestures may facilitate a child's language development (e.g., Goldin-Meadow, 2003). This may occur through the child's interaction with the parent, similar to child-directed speech or scaffolding.

This literature review will address the following bodies of research that are relevant to the relationship between gesture and oral language development: prelinguistic skills, including Bruner's three categories of communicative function, how gestures precede the child's first

words and predict the onset of two word phrases, and how gestures may facilitate oral language skills.

Gesture and Early Language Development

Gestures used by infants and toddlers are prelinguistic skills that meet Bruner's (1983) three categories of communicative function: to regulate behavior (by requesting objects or actions or protesting); to establish joint attention (by commenting and requesting information), and to initiate social interaction (by using representational gestures, attention seeking, and social games). But how do gestures aid children's language development? Two main areas are intentionality and joint attention (Owens, 1996).

Intentionality. Young infants (birth to eight months) first enter into the perlocutionay stage of language development. The infant vocalizes for attention, but does not have a goal of communicating with the parent. However, at the end of this stage, the eight month old infant begins to plan their communicative behaviors to achieve goals by using gestures: e.g., raising arms up to be picked up, looking at an adult, then looking at a desired object (Owens, 1996).

Illocutionary stage. Next, the eight to twelve month old infant begins to intentionally communicate with their parents in the illocutionary stage. The infant now gestures or vocalizes to express his or her intentions. Gestures are one behavior that is part of intentional communication. In this stage, infants show objects as a way to share attention with parents. At the end of the illocutionary stage, the infant uses a full range of gestures (e.g., giving, pointing, and requesting by reaching for object) to express himself. The eight to ten month old infant has two purposes for using gestures to communicate: protoimperatives (to request an object) and protodeclaratives (e.g., giving, showing, and pointing) to show joint attention with an adult (Lock & Zukow-Goldring, 2010).

Locutionary stage. The third stage of infant language development is the locutionary stage, and begins when the infant is twelve months old. Gestures are now accompanied by words, and may even be replaced by words in some instances. For example, the infant first points to a desired object in the locutionary stage, then vocalizes while pointing at the same time, then names the object desired, without the accompanying pointing gesture.

Research has shown that children's first words emerge from gestures, but also that gestures precede a child's first word by several months (Iverson & Goldin-Meadow, 2005). Gestures and words may assist the child in sharing a common social-cognitive infrastructure of joint attention and shared intentionality with his or her parents (Tomasello, Carpenter, & Liszkowski, 2007). This shared intentionality may allow infants to participate in communication, even before they produce words. In particular, the pointing gesture may serve as a transition device, moving the child from non-linguistic to linguistic communication.

During the second year of a child's life, gesture plus word combinations precede two-word phrase productions, and the gesture modality becomes elaborated before the verbal modality. This continues into the middle of the child's second year, when a rapid increase in words occurs, since the child now has the referential insight that words are labels for objects and actions. The child combines two words by the end of second year, and, at the same time, the child uses gestures less frequently. Gestures, however, do not disappear entirely, but instead take on a new role to express information that is not stated in the child's words.

Joint Attention

Gestures play another role in child language development: gestures aid the development of joint attention skills, which may be the best predictor of concurrent language ability. The first stage begins when the infant is four to six weeks old, as the mother places objects in child's field

of vision and calls attention to the object; next, the infant's gaze follows the caregiver's movements; in the second stage, the infant gestures (e.g., reaches for or shows objects) to gain the parent's attention. In the third stage, when the infant is eight to twelve months old, the infant begins to point and vocalize, which elicits language (e.g., questions) from the parent. As in the development of intentionality, the last stage of joint attention occurs when the child names objects (Owens, 1996).

In a comprehensive study of joint attention, Dawson et al. (2004) studied 145 children, aged three to four, who were placed into three groups: typically developing, children diagnosed with autism, and children with developmental delays. All participants were matched on mental age with the *Mullen Scale of Early Learning*. Another measure was the *Early Social Communication Scale* (ESCS), an assessment of social orienting. Items include calling the child's name or observing the child's response to a phone ringing. Joint attention measures, taken from the ESCS and the *Autism Diagnostic Observation Scale* (ADOS), involved tasks of sharing, and following and/or directing attention through eye gaze and/or gestures. Results revealed that the joint attention variable yielded the greatest separation between groups, followed by social interaction. Structural equation modeling showed that joint attention scores were predictive of concurrent language skills, as measured by the *Mullen Scales of Early Learning* for receptive language and the *Vineland* for expressive language.

Additionally, intervention that targets joint attention skills in young children and their parents may aid early language development. Holdgrafer, Kysel, and McCarthy (1989) found that the children with developmental delays produced more words after a five week intervention period, possibly due to parents expanding the child's utterances, and modeling in turn-taking exchanges.

Social Interaction and Gestures

Similar to Luria's theory of the development of deictic gesture in infants, longitudinal diary studies by parents may provide information about the interactions with their children that precedes gestures (Carpendale & Carpendale, 2010; Lock, 2010). In Carpendale and Carpendale's study, parents recorded the hand movements and gestures of two infants, one male and one female, from six to 14 months of age. At six months, one infant made a pointing gesture with his right hand while asleep, an indication that infants may form this handshape before it becomes a social gesture (Tomasello, Carpenter, & Liszkowski, 2007). At seven months, this infant extended his index finger to explore objects in his environment in an attempt to touch proximal objects. From nine to 11 months, one male infant pointed to distal objects that he was looking at, but this pointing was not yet social according to his parents, and appeared to be in conjunction with what he was attending to. Interestingly, the infant stopped pointing when he noticed that an adult was present. The infant followed his parents' pointing gesture by 12 months of age, and, at this stage of development, made requests by reaching with his arm extended, which was occasionally accompanied by unintelligible vocalizations. At 14 months of age, he began pointing to show an object to his parents, and to share attention to the object, but not to request it.

In the diary study of the nine month old female infant, she used her index finger to touch objects, and by 10 months of age, she began using eye gaze to point to her mother, who interpreted the eye gaze as a declarative gesture. She may have used the pointing gesture non-socially initially, but, through interaction with her parents, it became social**.** In addition, one male infant shook head for "no" and nodded for "yes" at 13 months of age. These head

movement gestures began as small head nods and shakes, but, as his parents responded to the gestures, his head movements became more pronounced.

Behavior Regulation

In Crais et al.'s (2004) longitudinal study of children gestures, researchers followed 12 Caucasian, monolingual, middle class children from six months through 24 months of age, over a period of 18 months. All participants had scores in the normal range on the *Bayley Scales of Infant Development-II*, in addition to parental report of their child's normal development on a developmental history form. Researchers trained the parents to complete the Gestural Recording Form (GRF), a parent report instrument designed to document gesture development. The GRF is based on Bruner's three categories of communicative function: to regulate behavior (by requesting objects or actions or protesting); to establish joint attention (by commenting and requesting information), and to initiate social interaction (by using representational gestures, attention seeking, and social games). Parents recorded their child's gestures on the GRF form, which consists of three sections: first, parents recorded which gestures their child used, and second, in which situations their child used the gesture; third, parents reported the age that their child first used the gesture. Parents' report on the GRF was confirmed during monthly in-home observations by the researchers, during tasks designed to elicit the specific gestures that were noted by the parents during that month. If the researcher observed the child using the gesture, either spontaneously or by facilitation, the child was credited as using that gesture. This procedure resulted in the researchers noting some gestures that had not been reported by the parent.

In a departure from the coding in similar studies, gestures were counted only when the behavior was directed towards an adult, and was aligned with one of Bruner's three

communicative functions. For example, a child's action was not counted as a gesture if the child reached for an object, but showed no notice of his/her parent. However, unlike similar studies ,the child was not required to exhibit eye gaze in order for his/ her action to be counted as a gesture (e.g., the child could direct their gaze towards the object he or she was pointing to, or simultaneously point and look at a picture in a book).

Results indicated that for eight out of the 10 children, protesting or pushing an object away, a behavior regulation gesture, was the first gesture to develop. The next gestures to emerge were social interaction gestures, with joint attention gestures emerging last. There was 91% agreement between parent report and the researchers' observations on all types of gestures. This in-depth study of young children's gestures provides a valuable developmental sequence and hierarchy for gestures, in accord with Bruner's categories of communicative functions.

Gestures Precede Words

Butcher and Goldin-Meadow (2000) examined the language and gesture systems of children in the early stages of language development. Six children, 13 to 28 months old, were followed longitudinally, from the beginning of the one word stage of language development to the beginning of the two-word stage. All vocalizations were coded, but only gestures that were empty-handed (not made with an object) were counted, plus the child had to establish eye contact with the parent for the movement to be counted as a gesture.

Five of the six children produced a larger proportion of gestures without speech at the beginning of the study, when the child was at the one-word phase of development, but by the end of the one word phase, most of the children used gestures in combination with speech. Additionally, two of the children transitioned from gestures without speech to gestures produced with speech over a two month period (Butcher & Goldin-Meadow, 2000).

In another longitudinal study with a larger sample size, Iverson and Goldin-Meadow (2005) examined children's complementary gestures (gestures expressing the same concept as the spoken word) and supplementary gestures (gestures that provide different, but related, information from the word). In the first of eight sessions, nine out of the 10 children produced the majority of references to objects in gesture only, and not speech. However, by the eighth session, all object labels were produced in speech, and no references were produced in gesture.

Averaged across all eight sessions, 50% of each child's reference to objects was in gesture only, as opposed to 25% in both speech and gesture, and 25% in speech alone, which suggests that children use gesture to refer to objects at a time in their language development when they do not produce the words for that referent. Next, the lexical items were classified as to whether they initially appeared in gesture or in speech, and if the concept moved from gesture into speech or speech into gesture. However, items that the child produced initially in both speech and gesture were excluded from this analysis. Analyses showed that items were more likely to appear first in gesture and then move to speech, and concepts were produced in gesture an average of three months before being produced in words.

Similar to results from comparable studies, all 10 children produced gestures plus word combinations before they produced two word verbal utterances, with a gap of between two and four months between the gesture and the word production. All 10 children produced both supplementary and complementary gesture plus word combinations before they produced two word utterances. There was a gap of 2.3 months between producing supplementary gesture plus word combinations, and 4.7 months interval between complementary gesture plus word combinations. These results lend support to the theory that gesture appears to work as a transitional device, moving the child to produce words and eventually, two word utterances.

Why is the Assessment of Gesture Use Important?

A growing body of research suggests that not only are gestures good predictors of later developmental or language disorders, but also that interventions that target gesture use can enhance oral language development. Both the quantity (e.g., Thal & Tobias, 1992) and the type of gestures (e.g., Goodhart & Baron-Cohen, 1993) may have diagnostic value. Specifically, the absence of giving, pointing, and waving may be a predictor of autism and is a diagnostic criterion in the DSM-IV (Filipek et al., 2000). It is feasible that assessing the quantity of gestures and separately assessing the type of gestures that a child uses may provide clinicians with different diagnostic information. For example, some researchers suggest that quantity of gestures is related to language delay (Thal & Tobias, 1992); or related to the amount of language the child produces (Sauer, Levine, & Goldin-Meadow, 2010); whereas Wetherby et al. (2004) found that the absence of the deictic gesture (pointing), and the lack of giving, pushing, or waving gestures were strong predictors of autism.

Quantity of gesture. Thal and Tobias (1992) studied children from ages 18 to 29 months at the one word stage of language development, in a re-analysis of data from their earlier study of eight children, with the addition of two more children. Language measures included the mean length of utterance (MLU), calculated from a language sample, the Early Language Inventory (ELI), and the Language and Gesture Inventory (LGI). The first task was imitation of single gestures, and in the second task, children imitated a series of gestures in familiar play schemes (e.g., feeding, bathing, and putting a teddy bear to bed).

Late talkers, defined as children who scored in the lowest ten percent for word production on the parent report instrument, the LGI, produced the same number of single gestures as language matched controls, but, significantly fewer gestures than age matched controls. This

result occurred even though late talkers scored higher on language comprehension tasks. Therefore, for children at the one word stage of language development, production of single gestures may correspond to production of words.

In the gesture schemes task, children who were late talkers fell between language and age matched controls on the total number of different schemes produced, and also in the number of gestures in the longest chain of a series of gestures. Late talkers were better than language-matched controls on sequence production, i.e., the number of different pairs of schemes produced in the modeled sequence. The results showed a disassociation between language and gestures for production of symbol sequences in play schemes, as well as a disassociation between gesture production and language production. Therefore, a child's gesture performance may be related to their word comprehension level, but not word production level, in carrying out a series of gesture sequences in play scheme.

At a one-year follow-up, four of the ten children continued to have delayed language production skills on the ELI, and were referred to as "truly late talkers". The remaining six children, who had progressed in their language development, were referred to as "late bloomers". When the two groups were compared, children who were truly late talkers performed significantly lower on all gesture tasks than the children who were late bloomers. The late bloomers used more gestures than the truly delayed late talkers, an indication that gesture may be a positive prognostic signal in a child's language development. Although one of the tasks appeared to be a symbolic play task, and not a gesture task, it is interesting to note that gestures differentiated children who had a persistent language delay from children whose language skills caught up. In addition, production of gestures in familiar play sequences were better predictors of an ongoing language delay than MLU and vocabulary skills.

Type of gesture. Since the type of gesture (e.g., deictic, iconic) appears to provide different diagnostic information than the quantity of gestures, Goodhart and Baron-Cohen (1993) studied the protoimperative pointing gesture, in which a child points to an object to obtain it, and the protodeclarative pointing gesture, in which a child shares something of interest with an adult, or points out an object that has caught the child's attention. These researchers discuss a third type of pointing gesture, referential pointing, similar to non-verbal naming. Twenty children, all diagnosed with autism spectrum disorder (ASD), and a comparison group of 20 typically developing (TD) children, ages two years and six months, were recorded in a two-minute session of pointing to pictures in a picture book. If the child did not point to pictures within two minutes, a verbal prompt was given by the examiner to elicit a pointing response. Ninety-percent of the children with autism produced referential pointing gestures, compared to the TD children, who used referential pointing 100% of the time in the research tasks. Regarding protodeclarative pointing gestures, 25% of the children with ASD used this type of gesture, compared to 90% of the children who were typically developing. Of course, the children with ASD were given only two minutes to point to the pictures, and may have pointed to the pictures if given more time to respond, or had the opportunity to point in other situations, such as pointing to a favorite toy. However, these results indicate that pointing may have diagnostic value, and the absence of protodeclarative pointing could be a diagnostic sign of language or developmental delay. It is suggested that the types of pointing gestures that a child uses be assessed in clinical evaluations.

Researchers have studied whether children who use more gestures produce more speech than children who use fewer gestures (Sauer, Levine, & Goldin-Meadow, 2010). Eleven children, all diagnosed with perinatal unilateral brain lesions (PL), ages 18 to 30 months of age, were compared to a group of 53 children who were typically developing, ages 18 to 26 months.

Each child was observed interacting with their parent in their home at 18, 22, and 26 months of age. All children were tested with the *Peabody Picture Vocabulary Test-III* (PPVT-III) (Dunn & Dunn, 1981) at 30 months of age. Spontaneous and imitated speech was recorded and spontaneous gestures were transcribed. Gestures that a child made to refer to different referents were counted as a separate gesture type. For example, if child pointed to a ball and a cup, this was counted as two types of gestures since each gesture had a unique meaning.

Results indicated that the deictic gesture was the most frequent gesture used by all children. There was no significant difference in the frequency of gestures between groups across all age levels. Next, the children with brain lesions were divided into two groups: those who scored at less than the 25th percentile for gesture production were in the low group; participants in the high group scored above the 25th percentile on gesture production at 18 months. When the two groups were compared on the speech production measure, the high gesture group produced more speech than the low group at the 22 month and 26 month age levels. However, these results may have been affected by the inclusion of imitated words along with spontaneous production of words. Since early gesture use predicted later receptive vocabulary skills when controlling for early speech, this may indicate that gesture and language have similar underlying cognitive skills involving symbolic systems. Importantly, in agreement with Thal and Tobias (1992), Sauer et al. (2010) suggest that measuring early gesture use may be one way to identify children who have language disorders. Taken together, these results indicate that children's gesture use should be assessed in clinical evaluations.

Gesture Predicts Vocabulary Development

In addition to having diagnostic value, children's gesture use may be related their later vocabulary development (Rowe, Ozcaliskan, & Goldin-Meadow, 2008). In-home observations of

parent-child dyads were held every four months over a 20 month period during each family's routine activities (playing, eating snacks, and reading books). Both parents' and children's words and gestures were transcribed, with gesture and word types as well as the frequency of words and gestures counted. They examined the type and frequency of children's gesture use at 14 months and compared it to vocabulary skills at 42 months on the *Peabody Picture Vocabulary Test* (PPVT), a measure of receptive vocabulary skills (Dunn & Dunn, 1981). Results indicated that PPVT scores were correlated with the children's word types at 14 months, and when word types were controlled, the child's type and frequency of gestures at 14 months were related to the PPVT scores at 42 months. In a regression analysis, the number of different words the children produced at 14 months explained only 12% of the variance in PPVT scores at 42 months. However, 27% of the variance in PPVT scores was explained by the children's gesture types. Additionally, the measure of parent gesture types had the strongest relationship to children's PPVT scores.

Next, sociocultural measures were assessed. Parent education and the family's income were significant predictors of PPVT scores, with parent education explaining 5% of the variance, and income level explaining an additional 6.8% of the variance, when controlling for child word types, child gesture types, and parent word types. In summary, children produced more gesture types (gestures with different meanings) when their parents produced more gesture types. Based on these results, the authors suggested that parents model gestures to their toddlers to enhance vocabulary learning (Rowe et al., 2008).

In a follow-up study, Rowe, Raudenbush, and Goldin-Meadow (2012) followed 62 children longitudinally, with participants aged 14 to 46 months, all raised in monolingual English-speaking homes. Children were videotaped for 90 minutes interacting in natural

situations with their parents during mealtimes, reading books, or playing with toys. Sessions occurred every four months and nine sessions were held in total. Transcriptions were made of each child's and parents' speech, in addition to the child's gestures, which were coded as deictic, representational (or iconic), or conventional gestures (e.g., head shake for *no*). Unlike other studies that count a gesture made with an object (Iverson & Goldin-Meadow, 2005), only empty-handed gestures were counted in this study. A gesture was counted when it referred to a different object (e.g., if a child pointed to a dog five times, this was counted as one gesture). Vocabulary words, however, were measured as cumulative word types over time. Thus, if the child produced a word at the 14 month observation session, he/she was credited with that word from that time period onward. Parent input was measured as the word types the parent produced during the child's 14 month observation session. This measure, unlike the child's vocabulary measure, was not cumulative. Hierarchical linear modeling (HLM) assessed the growth of children's vocabulary over time, with age centered at 2.5 years, the midpoint child age in the study. Two predictor variables, education and income, showed collinearity; therefore a Principal Component Analysis was used as a measure of SES.

Data were analyzed using a cubic model, the best fit of the data. Results showed that on average, children aged two years, five months have an estimated cumulative vocabulary of approximately 343 words types (child was credited with every word said from 14 months to two years, five months, even if he or she said the word only once). The acceleration of vocabulary growth was not constant over time, but rather increased each year, then decreased at the later ages of the study. As in the study by Rowe et al., parent input was significantly related to child gesture; family income, mothers' education level, and child gesture were significantly related to parent education. Children from families with higher income and education levels had greater

cumulative vocabulary skills at age two years, five months, and had faster rate of increase in vocabulary skills than children from families with lower SES. Surprisingly, parent input (parent word types) had only a marginal effect on vocabulary when SES was controlled, but child gesture showed a significant effect on vocabulary, controlling for SES and parent input.

Researchers administered the *Peabody Picture Vocabulary Test-III* (PPVT-III), a standardized measure of receptive vocabulary, before the children entered kindergarten, at 54 months. Children who showed faster acceleration of vocabulary in the study and increased vocabulary had a larger receptive vocabulary on the *PPVT-III* at 54 months, compared to children with slower rate of growth of vocabulary. Vocabulary skills are an index of readiness for school, and, since gestures at 14-30 months were strong predictors of vocabulary skills at two years, five months, these results could suggest that gestures were an indication of underlying language skills. Alternatively, the child's gestures may have led to increased vocabulary skills by eliciting more verbal feedback from the parents and, by 14 months, the children were socialized to gesture either more or less during interactions with their parents. In sum, Rowe et al. (2012) report a strong relation between early gesture use (at 14 months) and later vocabulary skills, an essential school readiness skill. Although a causal effect cannot be inferred, since parent input was significantly related to child gesture, and child gesture was related to vocabulary skills, the authors concluded that the children may have been socialized to gesture more (or less) during interactions with their parents.

However, the parent-child interactions in the study by Rowe et al. were not standardized, and variation in families may have accounted for these results, since children whose parents read more to them also had more parent input, even when the reading words were excluded from the

data. Therefore, children in families whose literacy levels or access to children's books are limited may have less verbal input.

Gestures and Parent Child Interaction

Evidence of the ways in which gesture use can aid children's language skills is derived from studies of parent-child interaction. For example, Iverson and Goldin Meadow (2005) analyzed data from their 2005 study of 10 children, previously reviewed, and analyzed videotapes of spontaneous play situations with the parents and child at mealtime. Gestures were coded as conventional gestures (e.g., "yes"; "no) and deictic gestures (e.g., child pointed to or held up objects to show the parents). Gestures were classified in multiple ways. First, objects that the child referred to in gesture only, and those the child had begun to refer to in speech were differentiated. Next, gestures and words were divided into two categories: gestures that reinforced speech (gesture and word express the same object) and gestures that supplemented speech (gesture and speech express different objects). In addition, each child's vocalizations were also coded and transcribed. In a departure from other studies, the mothers' immediate response to their child's utterances containing gesture was transcribed to determine if the mothers translated the child's gestures into words. The mother's MLU was also calculated.

Results showed that 75% of the objects that children referred to appeared first in gesture only. Children learned the words for two-thirds of their gestures during the study, and on average, three months after the child first produced the gesture. Next, mothers' verbal responses to the children's gestures were analyzed, and those gestures of the child that the mother translated into speech were compared to those gestures the mother did not translate into words. Analyses showed that the child was more likely to produce a word during the study when the mother translated their gesture into words than when the mother did not translate the gestures

into words. The *MacArthur Communicative Development Inventory* (MBCDI) (a standardized measure of child language skills) language comprehension scores were available for six of the 10 children. The authors concluded that the child's gestures signal the parents to say the word that the gesture refers to, with the children later expressing the words that were translated by the mother. Mothers' MLU was significantly longer in response to the child's supplementary combinations than their responses to the children's reinforcing combinations. Also, the mothers' sentences were longer when they incorporated information that the child conveyed in both speech and gesture, compared to the child's words without gesture, or gestures without words.

Children whose mothers produced a larger proportion of translated responses were also the first children to produce two word utterances. Although this may be reflective of the child's readiness to learn the word, as shown by the child's gestures, the mother's translation of the words may have facilitated the child's learning the word, or possibly gestures and language growth played a reciprocal role.

Another explanation was examined in Olson and Mazur's (2011) study of infants and mothers to determine if mothers responded to their child's gestures, how often, and in which contexts. Twenty-four parent-infant dyads, ages one year, one month old, two boys and 12 girls, including 23 Anglo-American and one African-American dyad, were videotaped in play situations in a language lab. All children had 65 or fewer expressive vocabulary words on the *MacArthur Bates Communication Development inventory*: Words and Gestures (*MBCDI*). None of the children were developmentally disabled, and all children showed at least a pointing gesture on the *MBCDI*. In order to elicit gestures, researchers used communicative temptations to coax the child to ask for the toy, or to ask for the activity to resume (e.g., blow more bubbles; activate the remote controlled toy.) Children's gestures were coded into protoimperative, proto-

declarative, or a third category, ambiguous gestures, when the meaning was not clear-cut. Mothers' responses to the infant's gestures were transcribed and analyzed for the communicative function (e.g., labeling of the object or naming an action).

The most frequent gesture that the children produced was extending an object to show their parents, followed by pointing, or reaching gestures. The mothers verbally responded more often when children used the protodeclarative gesture than when the gesture was ambiguous. The mothers also labeled the objects more when their child used a pointing gesture, and, in these instances, mothers were more likely to label objects and use internal state labels, with 95% of the internal state language concerning the infants' internal state. One conclusion is that infants' pointing gestures elicited mothers' labels of objects, which may advance children's vocabulary skills, lending support to the sociocultural theory that gestures and language develop through social interaction with the parents.

Parents model gestures. In an experimental study, Namy, Acredolo, and Goodwyn (2000) explored another possible explanation for gestures aiding a child's language development. Parents may gesture and produce words with equal frequency in joint attention interactions with their child. Eighty parent-child dyads, with children's average age of 15 months, participated in a picture book reading task. Fifty percent of the pictures were selected by the researchers to depict items that were unfamiliar to this age level of children, but were easy to gesture (e.g., 'binoculars'). The other half of the pictures were equally unfamiliar but selected to be less easily depicted in gesture (e.g., 'hot water bottle'). Half of the dyads were part of a research project that trained parents to incorporate symbolic gestures into their interactions with their young child. Parent-child reading sessions were videotaped and coded for the frequency of verbal and gestural labels of both parents and children. Only symbolic or iconic gestures were coded, but not deictic

gestures or head nods for “yes”. Another criterion for both verbal behavior and gestures was that the child and parent’s eye gaze must be directed towards the book. Reliability of coding was established by three coders, who independently coded 10% of the sessions in common.

Results indicated that, although parents used both verbal and gestural labels in the picture-book reading task, verbal labels were more frequent than gestures. Post hoc analysis showed that parents gestured more in action-type pictures (i.e., ‘jumping’) than in non-action type pictures, but produced more words for the non-action pictures. In contrast, the children produced very few verbal or gestural labels, and those gestures that they did produce were immediate imitations of their parents' gestures. One final result is that parents from the sign training group were significantly more likely to produce symbolic gestures than the control group.

One limitation of this study is the dyads were either seated side-by-side, or the infant was seated on the parent’s lap, which may have inhibited gestural production. In addition, the pictures in the book may have contributed to fewer gestures than if objects were used as stimulus, or, alternately, the picture stimuli chosen may have been more difficult in general for the parents to gesture. To assess these conclusions, a second study (Namy, Acredolo, & Goodwyn, 2000) with twelve parent infant dyads was conducted, but none of the participants had sign training previously. Children ranged in age from 11 to 13 months and participated in 15 minute videotaped free play sessions while seated on the floor with a wide variety of toys and books. Parent and child verbal labels were coded, but, as in the first study, only gestures that represented objects were coded, and pointing gestures were excluded. However, there was a slight variance from the first study: parents gestures were coded if they were made with an object (e.g., holding up a camera and clicking the button), but children’s gestures with objects were not

coded. The rationale for this coding scheme was that previous research showed that many of children's symbolic gestures are "abstracted" from routines that were originally performed with an object in hand (Goodwyn & Acredolo, 1998). Similar to the first study, gestural and verbal labels were coded only when joint attention was established between the child and the parent (e.g., both gazing at the same object). Results showed that the parents produced a high rate of labels, in both the verbal (2.8 per minute) and gestural (2.6 per minute) modalities. There was, however, no significant difference between the frequency of gestures in either modality, indicating that parents provided more gestural labels in the free-play with objects situation than in the picture book reading task. However, one difference was the frequency of parents' empty-handed gestures versus gestures made with an object. Parents' higher frequency of gestures with objects suggests that infants' first exposure to gestures is in routines with objects, as opposed to empty-handed gestures. In addition, it appears that the task of free play with toys may elicit more gestures from parents than reading a picture book to their child. Free play may also be a more interactive activity, compared to the more passive book reading activity.

Since the task of free play with toys elicited more gestures from parents than picture book reading, this appears to indicate that parents' production of gestures varies across contexts. Namy, Acredolo, and Goodwyn's (2000) study suggests that parents' gestures and words may be produced with equal frequency in joint attention interactions, which may account for young children's acquisition of both verbal and gestural communication. It is possible to view these results as support for Vygotsky's sociocultural theory of language acquisition, which also highlights the need to study children in everyday contexts with their parents, and not in laboratory situations.

Clark and Estigarriba (2011) examined the concept that parents integrate gestures with their speech, and may possibly match their gestures to different verbal content. Forty adult-child dyads, with the mean age of one year, six months for 20 of the children, and an additional 20 children with a mean age of three years, were videotaped in joint attention tasks with parents introducing novel objects to their child by labeling the object. Different objects were used for each age level; language measures were the MBCDI short form expressive vocabulary. Parents' gestures were transcribed as to trajectory and goal (e.g., pick up object and display with open palm) and adults' gaze. Adults' speech was coded into one of two categories: management talk (tracking what their child was attending to), or content talk (labeling or providing descriptions of an object's properties). Gestures that accompanied content talk were coded as either indicating gestures (pick up and hold out on palm or suspended) or pointing or touching or demonstrating gestures (showing how object moves or was used, typically made with the object).

In order to determine if there were differences in parental input according to age groups (one year olds and three year olds), the researchers analyzed parents' speech. Results indicated that parents used the same number of words with one year old children as they did with three year old children. However, the type of talk differed, since parents used more management talk with the one year old children, but more content talk overall. Analyses showed a significant interaction of talk type with age group. When speaking to one year old children, parents verbalized labels first 69% of the time, before providing supplementary information. Interestingly, parents frequently gestured during content talk; 85% of their gestures were indicating gestures; 87% were demonstrating gestures. However, parents used indicating gestures 79% of the time when offering further information, as opposed to using demonstrating gestures 21% of the time. There was no significant difference for age level.

In the three year old group, parents used approximately the same percentage of each type of gesture, which is similar to adult to adult interactions (Clark & Estigarriba, 2011). Parents matched the purpose of the gesture to their verbalization, by using indicating gestures 100% of the time when talking about parts or properties of an object, and demonstrating gestures 94% of the time when talking about actions or functions of an object. The researchers concluded that parents integrated content gestures with content talk by using both at same time, since indicating gestures were used for talking about parts and properties of objects, and demonstrating gestures were used for talking about actions or functions. An additional finding is that parents timed their gestures to occur with specific verbal content. Although this study added new gesture terms (e.g. indicating, demonstrating) to an already confusing array of terms (e.g., object vs. empty-handed gesture), results suggest that parents tailor their gestures to the content of their speech. One critical piece that could have been included is an analysis of the children's imitations, which may have shed light on the influence of parents' verbalizations on the children's vocalizations.

DeVilliers Rader and Zukow-Goldring (2010) hypothesized that gestures that parents produce in synchrony with words may direct the infant's attention during word learning. The sample included thirty two children, ranged in age from nine months through 14 months; 90% Caucasian; 10% were African-American, Asian-American, or Hispanic-American, all raised in monolingual English-speaking homes. All met the criterion of following a verbal command to look at one of their parents, or to look at a favorite toy. Children's eye movements were tracked by a sensor while they were shown videotapes of two novel toys, created for this study and named with a nonsense word. Each toy was presented for 35 seconds by videotape, and was accompanied by the direction to "Look at (toy name)". In the first experiment, the first test was to gauge where the children looked as the word was presented. A paired *t* test showed that the

children gazed at the object longer when the word was said when the speaker used a dynamic gesture (speaker moved object toward the child and then rotated the object), but children looked at the speaker's mouth longer in the static gesture condition (speaker held the object up towards their body, but did not move the object). Also, when presented with a dynamic gesture, children looked at the object more often than when presented with a static gesture, and also coordinated gazing at the object when the word was presented. Next, the children were asked to look at one of the objects, resulting in the younger children (12.5 months or younger) demonstrating better comprehension of the words than the older children, demonstrated by looking at the correct object, when the gestures were dynamic and presented in synchrony with the word.

A second experiment was conducted with 15 children, all with language scores normally distributed according to the *MBCDI.* The goal was to determine if the differences seen in the dynamic versus static gesture study were due to only the motion of the object, or whether the timing, or synchrony, with speech, was a factor. DeVilliers Rader and Zukow-Goldring (2010) compared dynamic and synchronous gestures to dynamic and asynchronous gestures, in which the gesture with the object was loomed towards the child at the same time that the word was presented. Paired *t* tests showed a significant difference between the synchronous and asynchronous dynamic gestures with an object, with children more likely to look at the object when the word was paired with the gesture than when the gesture and the word were asynchronous. The children spent the same amount of time looking at the objects in both conditions, with no significant difference between children looking at the mouth during presentation of the word or object. Therefore, it appears that the motion of the object drew children's attention away from the mouth and towards the object. Next, the data from the two synchronous conditions were combined and analyzed, along with data in the two non-

synchronous conditions. Results of a *t*-test showed that the two synchronous conditions were significantly different from chance, but the non-synchronous conditions were not significantly different. These results suggest that parents should use a showing gesture while moving the object in a dynamic movement, and pair their spoken words with their gesture to aid children's language development. Additionally, this study showed that when children direct their gaze to the object, and away from the speaker's mouth, this possibly further aids word learning.

Gesture training study. In addition to synchronizing gestures with words, Goodwyn, Acredolo, and Brown (2000) trained parents to gesture to their children, and examined the effects on language development. In accordance with sociocultural theory, the researchers hypothesized that children's gestures elicit more language from the parents. If this occurs, the more gestures and words the child has, the more opportunities there would be to elicit responses from parents. One hundred and three children were followed longitudinally from 11 months, and were seen at 15 months, 19, 24, 30, and 36 month intervals for language assessments. Children and their parents were divided into three groups. In the sign training group (ST), parents received instruction in the use of gestures, and also actively encouraged their child to use gestures; in this parent training, parents were told to make any gesture that made sense to them, and was easy to remember, rather than traditional symbolic gestures. Videotapes were shown to the parents as an example of gestures. A second group was the verbal training group, in which parents were encouraged to promote verbal language by labeling objects and using child- directed speech. The third group, the control group, did not receive training. Language measures were the *MBCDI,* the verbal vocabulary and measures of vocalization frequency during 15 minute play sessions with the child and his mother. All vocalizations were coded, and each child's mean length of utterance (MLU) was calculated at the 24 month session. The *Sequenced Inventory of Communicative*

Development (SICD) was one expressive and receptive language measure, and vocabulary was assessed by the *Receptive and Expressive One Word Picture Vocabulary Tests* (ROWPVT; EOWPVT). Next, gestures were coded, but "yes" and "no" gestures were excluded from the analysis, since they were considered to be universally acquired symbolic gestures, and the researchers wanted to target specific gestures. Toys were selected that represented five different object concepts, and were sent home with the parents and their children. Parents were interviewed every two weeks via phone and asked to describe their modeling efforts, their child's use of gestures or words, and if the child generalized communication to objects or pictures other than the stimulus toys.

Results showed that the children in the ST group acquired a mean of 20.38 symbolic gestures, in comparison to a mean of five gestures in the authors' previous studies, with similar measures. The ST group scored higher than the control group on composite receptive language scores on all measures across the span of the study, had significantly higher scores than the control group on the composite expressive language scores for most age levels, and was significantly ahead of the control group on MLU and nearly ahead on the longest utterance. There was a significant difference between the ST group and the control group on receptive and expressive language combined scores at 15 and 24 months of age, and this difference approached significance at 30 months of age. By 36 months, no significant differences were noted. Overall, the ST group outperformed the control group on more measures according to a *t* test, an unconventional analysis. MANOVA analysis showed no significant difference between the verbal group and the group that did not have any intervention training.

One conclusion was that symbolic gesturing facilitates the early stages of language development, and, as hypothesized, the child's gestures elicit language from the parent as the

parent acknowledges and elaborates on the child's gestures. One implication of these findings is that the child with 10 gestures and 10 words can elicit twice as many responses from parents as the child who has only10 words or only 10 gestures (Goodwyn, Acredolo, & Brown, 2000). This places new importance on the number of gestures that a child has as a stepping-stone to language development; an effect which appears to wash out by 36 months.

Summary

We have seen how gestures may be predictors of children's vocabulary skills. However, the question that arises next is "how do gestures transition the child to words?" Sociocultural theory may provide an explanation of how the relation between the child's gestures and his social interaction with his parents aids the child's transition to word production.

Gestures Facilitate Language Skills

Sociocultural theory states that the underlying structure of language is negotiated through parent-child social interaction. In child-directed speech, or motherese, the child babbles, which is interpreted as meaningful by the child's mother. In turn, the parent's interpretation facilitates the child's language acquisition. Similarly, when a child gestures, the parents also verbalize what the child gestured, which possibly aids language development (Iverson & Goldin Meadow, 2007; Olson & Mazur, 2011).

Child-directed gestures. Iverson and Goldin Meadow (2007) analyzed data from their 2005 study of 10 children, previously reviewed, and analyzed videotapes of spontaneous play situations with the parents and child at mealtime. Gestures were coded were conventional gestures ("yes"; "no) and gestures in which the child pointed to or held up objects to show the parents. Gestures were classified into two categories: object that the child refer to in gesture all only, and those the child began to refer to in speech. Furthermore, gestures and words were

divided into two categories: gestures that reinforced speech, and gestures that supplemented speech. In addition, each child's vocalizations were also coded and transcribed, plus, in a departure from other studies, the mothers' immediate response to their child's utterances containing gesture was transcribed to determine if the mothers translated the child's gestures into words. The mothers' MLU was also calculated. Results showed that 75% of the objects that children refer to appeared first in gesture only, but not in speech. Children learned the words for two-thirds of the gestures during the study, and on average, three months after the child first produced the gesture. Next, mothers' verbal response to the children's gestures were analyzed, and those gestures of the child that the mother translated into speech were compared to those gestures the mother did not translate into words. ANOVA showed that the child was more likely to produce a word when the mother translated their gesture into words (*M*=.77; SD=.22) than when the mother did not translate the gestures into words (*M*=.65; SD=.22). The same effect was found in children's gestures and in vocabulary words. Mothers were more likely to translate gestures his verbal equivalents became part of the kids vocabulary during this study then gestures whose verbal equivalents did not become part of the child's vocabulary. *MacArther Communicative Development Inventory* (MBCDI) language comprehension scores were available for six of the 10 children. Mothers translated 42% of the words that were not in the child's comprehension vocabulary. The authors concluded that the child's gestures signal the parents to say the word that the gesture refers to, with the children later expressing the words that were translated by the mother. Mothers MLU was significant significantly longer (*M*=3.73; SD=1.26) in response to the child's supplementary combinations than their responses to the children's reinforcing combinations. Also, the mothers' sentences were longer (MLU =5.68

words) when they incorporated information that the child conveyed in both speech and gesture, compared to the child's words without gesture, or gestures without words.

Children whose mothers produced a larger proportion of translated responses were also the first children to produce two word utterances (r_s=.93, p<.01). Although this may be reflective of the child's readiness to learn the word, a shown by the child's gestures, the mother's translation of the words may have facilitated the child's learning the word, or possibly gestures played a causal role and language acquisition.

Another explanation was examined in Olson and Mazur's (2011) study of infants and mothers to determine if mothers respond to their child's gestures, and how often, and in which contexts. Twenty-four parent-infant dyads, ages one year, one month olds, two boys and 12 girls, including 23 Anglo-American and one African-American dyad, were videotaped in play situations in a language lab. All children had 65 or fewer expressive vocabulary words on the *MacArthur Bates Communication Development inventory*: Words and Gestures (*MBCDI*). None of the children were developmentally disabled, and all children showed a pointing gesture on the *MBCDI*. Researchers used communicative temptations to elicit gestures, such as bubbles or remote controlled toys. Children's gestures were coded into protoimperative, proto-declarative, or ambiguous gestures. Mothers' responses to the infant's gestures were transcribed and analyzed for the type of verbalization (e.g.: labeling of the object or naming an action).

The most frequent gesture that the children produced was extending an object to show their parents, followed by pointing, or reaching gestures. The mothers verbally responded to all the infants' gestures, in all communication contexts, and to all gestures gesture types. However, the mothers responded verbally more often when children used the protodeclarative context than the ambiguous context. The mothers also labeled the objects more when their child used a

pointing gesture, and, in these instances, mothers were more likely to label objects and use internal state labels, with 95% of the internal state language concerning the infants' internal state. One conclusion is that infants pointing gestures elicited mothers' labels of objects, which may advance children's vocabulary skills, lending support to the sociocultural theory that gestures and language develop through social interaction with the parents.

Gestures Scaffold Language Development

Parents scaffold, or support young child's communication structure, allowing the child to communicate efficiently, despite the child's more primitive linguistic system (Bruner, 1983). As shown in Goodwyn and Acredolo's (1998) study, parents scaffold their child's language skills by motivating their child to communicate in any form, either words or gestures. Thus, gestures may serve to increase the child's motivation to talk; as well as to scaffold the child's language by helping the child gather information about the symbolic function of objects. Also, the child's gestures control the topic of conversation around which the joint attention episodes are organized, which contribute to a faster rate of language development since the child's gestures aid the parent to recognizing the topic that their child wants to talk about, and therefore parents can match their language input to that topic (Goodwyn, Acredolo, & Brown, 2000). The researchers concluded that gestures themselves scaffold a child's communication skills by helping the child gather information about symbolic function of objects in their environment.

Gestures and child-centered topic. In order to facilitate a child's language development, parents of both children with typically developing language skills and parents of children with communication disorders use more child-focused utterances, related to what the child is looking at or talking about, rather than utterances unrelated to what the child is attending to (Watson, 1998). Participants were 14 mother-child dyads, and all the children were diagnosed

with autism by psychologists on the *Childhood Autism Rating Scale* (CARS). Eleven boys and three girls, ranging in age from two years, six months to five years, 10 months, had receptive and expressive language skills ranged from less than one year to two years, eight months on the *Reynell Developmental Language Scale*. The control group, 14 preschool aged children, all with typical development, were observed in 15 minute free play sessions. Verbalizations were recorded and transcribed via the Systematic Analysis of Language Transcripts (SALT), and mothers' verbalizations were coded as child-focused, out of focus, or other verbalizations. The results showed that the mothers of the children who had autism used more utterances overall, plus more of their utterances were directed at objects that were out of their child's line of sight than the utterances of the mothers of the children who were typically developing. Watson's explanation for these results is that the mothers' utterances that were out of focus may have been their attempt to establish joint attention with their child, who experienced difficulty with this skill. Applied to children's gestures, the child's gestures may center the topic around the child's interests (Goodwyn, Acredolo, & Brown, 2000). Parents' gestures may focus the child's attention on the object that the parent is teaching the child, but the child's gestures enable the child to direct the joint attention, by enabling the parent to know the topic that the child wants to talk about. This contributes to the child's language development, since parents can now match input to topic (Goodwyn et al.).

Cultural Differences in Gesture

Conventional gestures (e.g. "yes", "no," "good", or "hello") are usually culturally defined (Capirici & Volterra, 2008). For example, speakers in the United States nod their heads to indicate "yes", but this same gesture means "no" in Turkey. In Greece, speakers indicate "yes" by raising their eyebrows, whereas in other countries, "yes" is gestured by pointing the lip or

chin (Tomasello, Carpenter, & Lizkowski, 2007). Pointing in the United States is typically made with the index finger, and generally made with the right hand (Bates & Dick, 2002), but in other countries, speakers point with their whole hand (Kendon, 2004). The conventional gesture of thumb pointing upward connotes "good" in the United States, however in Germany, thumbs up indicates the number one, and in Japan, number five.

Gestures of bilingual speakers. Bilingual speakers may gesture more than monolingual speakers, and, in particular, use iconic gestures. However, speakers who are bilingual in French and English may use more deictic gestures while speaking their second language (Pika, Nicoladis, & Marentette, 2006). Italian is considered a gesture rich language, (Iverson, Capirici, Volterrra, & Goldin-Meadow, 2008)) and children raised in the Italian culture could be expected to gesture more frequently than children in other cultures. Iverson et al. examined three Italian children and three English-speaking children from the United States, and followed the children longitudinally over six sessions. Videotaped sessions, 30 minutes long, were made of the children playing or during mealtimes. Results showed that the two groups did not differ in the number of referents that were expressed in gesture, however, the American children produced primarily deictic gestures, compared to the Italian children, who produced more representational gestures, and had an equal number of deictic and representational gestures. Further analysis showed that the American children's representational gestures were conventional ("hi" and "no") whereas a substantial proportion of the Italian children's representational gestures were iconic (e.g., flapping arms to indicate "bird"). Next, the vocabulary skills of both groups of children was measured by counting the total number of different word types of each child in the five month period before the onset of two word phrase production. Interestingly, the Italian children produced fewer spoken words than the American children. The authors offered one explanation

for these findings: Italian children's expressive vocabularies may be smaller than American children because they use more representational gestures, with gestures substituting for words.

Gesture and Socioeconomic Status

Hart and Risley (1995) report language differences in various socioeconomic status (SES) groups. Children whose parents were professionals had three times more language interaction with than did children from lower SES homes. In addition, the children heard a greater variety of types of words, multi-clause sentences, and more past and future tense verbs.

Similarly, Rowe Ozcaliskan, and Goldin-Meadow's (2008) found differences in gesture use in children from different SES. Results indicated that the child's use of gesture correlated with SES, with children from higher SES homes using more gestures. Additionally, children's gesture use at 14 months correlated with receptive vocabulary at 54 months on the *Peabody Picture Vocabulary Test* (PPVT), which explained higher vocabulary skills.

Summary

Similar to the existing research on children's language skills, research indicates there are differences in gesture use with children from different cultures and SES groups. Since there is evidence that gestures have diagnostic value in assessing children, clinicians may consider the type and quantity of gestures a child uses during a clinical language assessment. There are several ways that this could be achieved: first, by parent report; second, by administration of standardized assessments that use the parent report format. However, the method of assessing gestures may differ in a research study vs. in clinical practice. Examining assessment of gestures in both settings, as well as the validity and reliability of current standardized tests that assess gestures, should be a focus of a thorough review.

Variation in Methods for Measuring Gesture Use

In general, these studies' findings converge on the interactive and reciprocal effects of gesture and oral language development, as well as the important role of parent gestural and language input for children's vocabulary, a school readiness skill, and receptive and expressive language development. However, the interpretations of and implications from these studies are muddled by the wide range of methodological approaches; e.g., variations in definitions of gestures and conflicting coding schemes, different procedures, and study designs. The most crucial issue is that what constitutes a gesture varies from one study to the next. Consequently, gestures are coded differently in each study. For example, some studies coded only empty-handed gestures (Namy, Acredolo, & Goodwyn, 2000; Olson & Mazur, 2011; Rowe, Raudenbush, & Goldin-Meadow, 2012). One study excluded the pointing gesture completely (Namy et al., 2000) while another study divided the pointing gesture into three different types: protodeclarative, proto imperative, and referential (Goodhart & Baron-Cohen, 1993). In addition, several studies excluded conventionally acquired gestures such as *yes* and *no* in an effort to target specific gestures during the study (Goodwyn, Acredolo, & Brown, 2000).

Another issue is variation in the taxonomy of gestures. In Clark and Estigarriba's (2011) study, they classified gestures as indicating and demonstrating, neither of which are terms typically seen in the gesture literature. In addition to differences in coding schemes, Crais et al. (2004) counted gestures only when they were directed towards an adult, but did not, however, require the child to use eye gaze. Since young children often gesture without eye gaze, some gestures may have been missed.

Additionally, there is considerable variation in methods used to collect data on gesture. Most research studies have videotaped parent and child interactions, and later analyzed the

gestures in a research lab (Olson & Mazur, 2011; Iverson & Goldin-Meadow, 2005; Namy, et al., 2000). Interestingly, some of the free play studies have selected toys specifically for the study in order to elicit specific gestures (Clark & Estigarriba, 2011; Namy et al., 2000). In contrast, the study by deVilliers Radar and Zukow-Goldring (2010) used novel toys, and furthermore, invented nonsense names for the novel toys for their study. Goodhart and Baron-Cohen (1993) analyzed gestures the children and parents produced in a two minute pointing to picture book task, a situation that did not elicit many gestures.

Feasibility of parent report measures. While videotaping gesture use during parent-child interactions is typically used for research purposes, this approach would not be practical for clinical purposes. An alternative is the use of parent report, an approach that has been shown to be reliable and valid in the assessment of children's oral language development (Crais et al., 2004). Some evidence suggests that parent report may also be a clinically useful approach for assessing gesture use. For example, Crais et al. (2004) used a parent report instrument, later confirming that the child used each gesture reported by the parents with in-home observation by the researcher.

Ring and Fenson (2000) studied one parent report of language test, the *MacArthur Bates Communicative Development Inventory* (*MBCDI*). Parents completed a checklist consisting of the same words in the picture identification task, and were asked to identify which words their child would be able to comprehend and to label verbally, as a measure of expressive vocabulary, prior to completing the (*MBCDI*). The correlation between parent and child mean proportion accuracy scores was moderate (r =0.67) for expressive vocabulary and comprehension (r =.55). Parents' estimates of their child's vocabulary production were higher than the child's performance on the picture identification task on all levels of difficulty. This suggests that the

children's performance was overestimated by parents. One other finding was that the *MBCDI* was a better predictor of child performance on the picture identification task than parental report, since regression analysis showed that parental judgment did not account for additional variance after the *MBCDI* score was taken into account. The correlation between the children's comprehension and production scores was moderate (r =.53), but for the parents, the correlation between their judgment of comprehension and production was lower (r =.41), suggesting that parents judged comprehension separately from production skills.

Although it could be argued that some of the vocabulary words chosen for the picture identification task, such as “full” and “old”, do not appear to be at the vocabulary level of 20-30 month old children, the ages in the sample, the results suggest that parents may be inaccurate reporters of their child’s expressive and receptive language skills, and may overestimate their child’s performance.

In a series of interviews with 14 Mexican immigrant mothers, whose children (aged 17 to 47 months) were receiving center-based speech and language therapy, mothers did not accurately report their child’s receptive language deficits (Kummerer, Lopez-Reyna, & Tejero Hughes, 2007). Mothers generally reported that their child’s receptive language skills were intact, although their child was delayed in receptive language according to standardized measures. However, the mothers were able to identify other areas of their child’s communication disorders, such as articulation, as well as their child’s gains in intervention. Therefore, in accord with Reese and Read (2000), Kummerer et al. (2007) recommend that it may be beneficial for clinicians to educate parents about receptive language skills. This suggests that clinicians need to use caution in using parent report tests to assess receptive language skills with all populations of children.

Results, however, are conflicting regarding the accuracy of parent report of children's language skills with children from minority groups (Pan et al., 2004; Roberts et al., 1999), and for children whose mothers have low education levels (Reese & Read, 2000; Reilly et al., 2006) or low socioeconomic status (Arriaga et al., 1998; Reilly et al., 2006). One explanation for parents reliably reporting their child's expressive language skills (Feldman et al., 2005), but not receptive language skills (Kummerer, et al., 2007; Ring & Fenson, 2000) may be due to the complexity of receptive language in older children (Ring & Fenson, 2000). Another argument is that parents may confuse their child's receptive and expressive skills, thereby conflating the results (Reese & Read, 2000). For these reasons, Feldman et al. (2000) advises researchers and clinicians to use caution in interpreting the results of the *MBCDI* to identify children at risk for language delay or to evaluate interventions.

Conditions for parent report. Based on the decade-long development of a parent report instrument for language assessment, the *MacArthur-Bates Communicative Development Inventory* (*MBCDI*) (Dale, Bates, Reznick, & Morisset, 1989) recommend five general conditions for effective use of parent report. First, parents should assess the child's current language skills, not retrospective behaviors, since current information is more reliable. Clinicians should ask parents about newly emerging skills that are easily to observe, since skills such as receptive language are more difficult for parents to reliably observe. Third, parent report measures should use a recognition format, in which a list of words is presented and parents identify which words their child says or comprehends, rather than a recall format, where parents are asked to recall words that their child knows. Fourth, clinicians should probe for specific examples of how the child uses a word. Finally, Dale et al. caution that researchers and clinicians should evaluate the results of parent report in view of how the information will be used, since

both concurrent and predictive validity decrease when short forms of parent report tests or interviews are used (Dale et al., 1989).

There are several ways that meeting these conditions could be achieved: first, by administration of standardized assessments that use a parent report format, and second, by informal checklists designed for parents. One checklist that assesses gestures is the Gestural Recording Form (GRF), which combines clinical observation with parent report to assess children's gestures. Crais et al. (2004) developed the Gestural Recording Form (GRF) in a recall format as opposed to a recognition format, and included gestures with objects along with empty-handed gestures. As in other tests that incorporate gestures, the GRF includes some gestures that could be classified more as social routines, as opposed to communicative gestures (e.g., child placing diaper on head). Additionally, parents reported difficulty in distinguishing between gestures produced with or without vocalizations.

Standardized Tests that Use Parent Report to Assess Gestures

MacArthur-Bates Communicative Development Inventory. There are three standardized language tests that include a parent report measure of gestures in their test items. One of the earliest parent report format tests, the *MacArthur-Bates Communicative Development Inventory* (MBCDI) has two scales, and the infant form, the Words and Gestures (WG) subtest, consists of 12 items that ask parents if their child uses gestures. However, some of the gesture items could be considered symbolic play actions (e.g., "Smacks lips in a 'yum yum' gesture to indicate that something tastes good") and not communicative gestures.

Predictive validity. Thal, O'Hanlon, Clemmons, and Fralin (1999) did not find validity for the WG subtest as a means of assessing gestures. Additionally there was no significant correlation between the WG and gesture imitation scores in a spontaneous language sample.

However, the *MBCDI* may have predictive validity for children with autism. Sixty-two children diagnosed with autism were assessed with the *MBCDI* Words and Gestures or Words and Sentences at two years of age, again at three years of age, and finally at age nine as part of a longitudinal study of autism (Qiu, Lopez, & Lord, 2007). Nineteen children diagnosed with developmental delay, i.e., the comparison group, were assessed with a variety of measures appropriate for their age level, including the *Clinical Evaluation of Language Fundamentals* (CELF) the *Sequenced Inventory of Communication Development*, and the *Reynell Developmental Language Scales*. Age equivalencies were calculated for this group of participants, with acknowledged limitations of age equivalency scores, since standard scores were not available because many of the participants exceeded the chronological age for the test's norms. Predictor variables on the *MBCDI* for the two and three year old children were the number of pre-speech items the parents reported that the child mastered ("responds to name", and "responds to 'no-no'"), the number of words the child understood, and the presence of expressive language, defined as parental report of at least one spoken word. At age two, only 48.9% of the children with autism met these criteria for expressive language, and by age three, only 70.59% met the expressive language criteria. In contrast, 78.95% of the developmentally delayed children produced at least one spoken word (Qiu et al., 2007).

Another predictor variable was early and late appearing gestures, as measured on the Words and Gestures subtest of the *MBCDI* (Qiu et al., 2007). Regression analysis showed that, for the children with autism, the *MBCDI* receptive and expressive language scores at age two accounted for a significant amount of variance in the prediction of scores at age nine, with expressive language showing a stronger relationship to all outcome variables than receptive language. However, by age three, receptive and expressive language variables were comparable

in predictive ability. The number of later occurring gestures at age two predicted expressive language skills at age nine for the group of children with autism. For the children with developmental delay, neither receptive and expressive language scores nor the number of gestures produced at ages two and three predicted later outcomes.

Communication and Symbolic Behavior Scale (CSBS). Wetherby and Prizant (2002) based the Communication and Symbolic Behavior Scale (CSBS) on research on the MBCDI in 1993, and a later, shortened version is the Developmental Profile (DP). Seven precursors of language development were divided into three composites: The social composite includes emotion and eye gaze, communication, and gestures. The speech composite includes sounds and words, and the symbolic composite tests the child's understanding of language and object use (Wetherby, Allen, Cleary, Kublin, & Goldstein, 2002). The developers of the CSBS DP used the parent report format and a naturalistic environment to test the child to reduce factors that may interfere with test results ecological validity, e.g., stranger anxiety.

The *CSBS DP* consists of three parts. The Infant-Toddler checklist (ITC) is a screening tool to determine if the child needs further evaluation. It is a one-page form consisting of 24 questions about the child's social communication skills. The social composite includes gestures on the ITC. The *CSBS DP* is designed to be ecologically valid and uses a recognition format. The second component is the Caregiver Questionnaire (CQ), which is the parent report companion to the Behavior Sample (Carey, 2005), and asks parents more in-depth questions about their child's language skills. The Caregiver Questionnaire consists of 36 words reported with the highest frequency on the *MCDI* (Wetherby et al., 2002). The CQ is a recognition format in which items are statements that the parent indicates that he or she has observed (Carey, 2005). The third part of the test, the Behavior Sample (BS), is a face-to-face evaluation with a speech-language

pathologist. The Behavior Sample (BS), in conjunction with the Infant-Toddler checklist and the Caregiver Questionnaire, determines if the child has a language disorder. However, the normative sample of the CSBS DP underrepresented families of low SES, and families whose mothers had low education levels, which decreases the validity of inferences for children from these families. There are however, only five gesture items in the Infant-Toddler checklist, which may not be a comprehensive assessment of gestures.

Rossetti Infant Toddler Language Scale. The *Rossetti Infant Toddler Language Scale* (Rossetti, 1990), is a criterion- referenced language test which results in a basal score for six domains, including language comprehension, language expression and gestures. Although the *Rossetti* lists gesture as one of the six domains tested, several of the items in this domain appear to assess play and self-care skills**.** For example, at the 18 to 21 month age level, an item in the gesture domain includes putting on clothing and pretending to dance to music, neither of which is considered communicative gestures in the current literature. Other items in the gesture domain may be considered measures of symbolic play. Also, in addition to the domain of gestures, both the receptive language and expressive language domains contain items about gestures. Therefore, the clinician needs to search several sections of the test form to identify which gestures a child does or does not currently use.

III. METHOD

Participants

Growing Baby study. Participants were part of an existing data set from an ongoing study, i.e., "The Growing Baby study: Changes in autonomic and behavioral regulation in infants between ages 6 to 36 months" (Porges, 2008). Conducted at the Brain-Body Center at the University of Illinois at Chicago, and funded by the National Institute on Child Health and Human Development, this longitudinal study evaluated whether the regulation of autonomic state distinguishes persistent criers from other infants, and whether persistent crying during infancy predicts a compromised developmental outcome. In addition, the original study addressed the possibility that if autonomic regulation is linked to persistent crying and is predictive of developmental outcome, an objective test of autonomic regulation could be useful in the clinical setting.

Research personnel from the Growing Baby study recruited families from the metropolitan Chicago area via newspaper advertisements and brochures. Participants in the Growing Baby study were children between the ages of four months and two years at the time of recruitment. This study excluded children with known neurological, medical and genetic disorders, and children with Apgar scores of seven or lower. Participants in this study were then followed at yearly intervals, from six months through 36 months of age. Incentives to participate in the study were financial compensation (fifty dollars per completed research session, plus ten dollars for parking or transportation), a child sized t-shirt, and a DVD recording of excerpts from their child's research session.

A researcher in the Growing Baby study conducted a telephone screening interview to determine each participant's eligibility to participate in the study. A research assistant mailed behavioral questionnaires, including the *Checklist of Children's Gestures* (Appendix A) and the *M-CHAT* (Appendix B), to the participant's home one week before the scheduled research session. Parents were asked to complete the forms at home and to bring them to their child's first research session. A research assistant obtained informed consent from the parents when they arrived at the UIC Brain-Body center for their child's first session. A research assistant from the Brain-Body Center also administered the *Bayley Scales of Infant and Toddler Development-III* during the second research session. The researcher for the present study was not directly involved in the data collection procedures.

Demographic data on participants' age, gender, and race, the family's socioeconomic status, and the highest education level of the child's primary caregiver were collected by the Growing Baby study. At the time of the child's first evaluation, parents completed a demographic information form, which included child's age, gender, and ethnicity, the highest education level of the child's primary caregiver, and family socioeconomic status. The Growing Baby study coded socioeconomic status according to family income, and whether the family received public assistance (See Appendix C). For all but nine of the families, the mother was reported as the primary caregiver, and most likely was the person who completed the *Checklist of Children's Gestures and M-CHAT* form.

Present study participants. The *Checklist of Children's Gestures* was added to the Growing Baby study's IRB in September, 2010, when the participants were 24 or 36 months of age (Appendix D). Since that time, one hundred and ninety-nine parents completed the *Checklist of Children's Gestures*, with their children's ages ranging from 24 to 36 months of age.

Approximately 17 checklists were incomplete, and were therefore excluded from this study. The present study used an Ex post factor design, since data were collected during the Growing Baby study. However, the research questions differed from the original study's questions.

To describe the sample for the present study, descriptive statistics were performed to determine means and standard deviations of the demographic variables for the sample. The total number of participants was 179. The sample consisted of 49.2% males and 43.6% females. The child's language environment was determined by whether the parents reported that their child was in an English language learning environment (68.2%) or if their child was in a bilingual environment (24.6%). Based on ethnicity parent report, 38% of the children were Caucasian, 30.2% were African-American, 14% were Hispanic, and 8.9% reported their ethnicity as "other". Regarding children's age, 54.2% of the sample was 24 months old, and 45.9% was 36 months old.

The highest level of education of the child's primary caregiver was assessed (see Appendix C). For 35.8% of the sample, the primary caregiver had a graduate degree, 28.5% attended college for one to three years, 24.6% completed four years of college, 4.5% completed high school, and 3.4% had completed 10-11 years of school. Data were missing for six participants.

Regarding socioeconomic status (SES) for this sample, 38.5% reported an annual income above $50,000 but below $100,000, 25.1% reported an income level below $50,000, 17.9% reported income of over $100,000, and 13.4% reported receiving public assistance. SES data were missing for 5% of the families (Table I).

Participants Receiving Speech-Language Therapy Services

One question that arose was how many of the participants received speech-language therapy services at the time their parents completed the *Checklist of Children's Gestures*. This would be a possible threat to the validity of the study, since some of the gestures on the checklist may have been taught to the children during speech-language therapy sessions. Although not included as a question in the Growing Baby study, research assistants recorded parental report of whether their child was currently receiving speech-language or other therapy services. This information was volunteered during administration of the *Bayley Scales of Infant and Toddler Development* receptive and expressive language subtests. When reported, the research assistant recorded the information on the hard copy of the *Bayley* test form. Results indicated that six of the 179 participants were reportedly in speech-language therapy at the time that their parents completed the *Checklist of Children's Gestures.* One additional participant was scheduled to begin speech-language therapy in the near future, and one parent reported that their child had been referred for a speech-language evaluation, but had not yet begun services. (As two participants' *Bayley* test forms could not be located, the number of children receiving speech-language services, or referred for services, could possibly be higher than reported here). The incidence of preschool aged children receiving speech-language therapy services ranges from two to 19% of the population (asha.org); therefore, in the present study, six children out of 179 falls within this range, indicating that this was a representative sample.

All six participants were male (100%), 83.3% were two years old, 16.7% were three years old, and 50% were bilingual. All six participants passed the *M-CHAT*. The sum of language scaled scores on the *Bayley III* ranged from 12-27, with a mean of mean scaled score of 18.8. According to the manual (Bayley, 2006), the scaled scores on the *Bayley* are derived from

raw scores, with a mean of ten and a standard deviation of three. This may be an indication that the six participants were not receiving language therapy.

In addition, the total gesture scores for the six participants receiving speech-language therapy ranged from 11-17 (out of a possible18) on the *Checklist of Children's Gestures*, with a mean of 13.8 for the six participants receiving speech-language therapy during this study. A frequency analysis of the gestures these six participants did not use, per parent report, showed that 0% held up fingers for their age, 83% did not use the gesture "holds hands up for 'stop'". Also, 50% of the participants who received speech-language therapy during this study did not use the gesture for "quiet", "me, my turn" or "stomps feet when mad".

Measures

Three major measures of children's development were used to address the research questions: the *Bayley Scales of Infant and Toddler Development-III* (Bayley, 2006), the *Modified Checklist for Autism in Toddlers (M-CHAT*) (Robins, Fein, & Barton, 1999), and the *Checklist of Children's Gestures* (Brann, 2009) (see Appendix A).

Bayley Scales of Infant and Toddler Development-III. The *Bayley Scales of Infant and Toddler Development-III* (Bayley, 2006) is a widely used assessment of cognitive, language, and motor skills of children between one month and 42 months of age. This test addresses all five developmental area required by the Individuals with Disability Education Act (IDEA, 2004): cognitive, language, motor, social-emotional, and adaptive behavior. The *Bayley-III* is individually administered by a trained clinician, and its primary purpose is to determine whether a child is developing typically. There are two language subtests: the receptive communication and the expressive communication subtest. The receptive communication subtest examines how a child responds to sounds (e.g., a person's voice, rattle), and understands spoken words and

directions. The expressive communication subtest assesses how a child names pictures and answers questions, and for older toddlers, uses grammatical forms such as past tense and the plural form of nouns. The items on the receptive and expressive language subtests are similar to items on other standardized language tests, such as the *Rossetti Infant-Toddler Language Scale* (Rossetti, 1990) and the *Preschool Language Scale-4.* In fact, the test manual states that a number of items for the receptive and expressive subtests of the *Bayley–III* were adapted from the *Preschool Language Scale.* The testing procedure is that the clinician gives a stimulus in the form of an object or a picture, and the child responds to the stimulus by either pointing to the word named, or naming the picture.

Each subtest results in a scaled score, a composite score, and percentile rank. Scaled scores represent a child's performance on a subtest in relation to his or her same aged peers. Since both percentile ranks and composite scores have limitations, e.g., percentile ranks do not have equal intervals and composite scores tend to cluster near the median, scaled scores on the *Bayley–III* were used to obtain the most accurate description of the children's performance (Bayley, 2006*).*

Reliability of the *Bayley-III*. Evidence of the internal consistency of the *Bayley-III* is shown by the split-half method. As reported in the manual **(**Bayley, 2006), the reliability coefficients are r =.91 for the cognitive subtest, r =.87 for the receptive language subtest, and r =.91 for the expressive language subtest (Bayley, 2006). Test-retest reliability using the Pearson's product moment correlation coefficient was reported as follows: for the cognitive subtest, corrected r =.71, Cohen's d =0.40; for the receptive language subtest, corrected r =.70, Cohen's d =.21; for the expressive language subtest, corrected r =.80, Cohen's d = .23.

Validity of the *Bayley-III.* Evidence of content validity was provided by expert reviews of the items on the receptive and expressive language subtests to ensure that they fit the domains that the *Bayley-III* is intended to measure. Construct validity was determined by the intercorrelations between the subtests. There was a moderate correlation (.53) between the receptive and the expressive language subtests. For the cognitive subtest, there was a .50 intercorrelation with the receptive language subtest and .45 with the expressive language subtest. Confirmatory factor analysis of the normative sample of the *Bayley-III* resulted in goodness-of-fit statistics of chi square of 10.23 for all age groups, indicating good relationships between observed scores and the latent variables of language, motor, and cognition. Concurrent validity was demonstrated by administering the *Preschool Language Scale-4* (*PLS-4*) to sixty-nine children ranging in age from five months to 42 months (Bayley, 2006). A high correlation was reported between the language composite of the *Bayley-III* and the expressive communication subtest of the *PLS-4* (.71), and moderate correlations (.51) with the auditory comprehension subtest of the *PLS-4* and between the receptive language subtest of the *Bayley* and the auditory comprehension subtest of the *PLS-4* (.62). Low, but significant correlations (.40) were seen between the expressive language subtest of the *Bayley-III* and the expressive communication subtest of the *PLS-4* (Bayley, 2006).

***Modified Checklist of Autism in Toddlers* (M-CHAT).** The *Modified Checklist for Autism in Toddlers (M-CHAT*) is a parent report checklist of symptoms that are considered autistic-like (Robins, Fein, & Barton, 1999) **(**see Appendix B). The test is made up of 23 items with a dichotomous (yes/no) response format. Six of the 23 items are considered critical items, e.g., “Does your child take an interest in other children?”; “Does your child respond to his/her name when you call?” The *M-CHAT* is validated for screening toddlers from 16 to 30 months of

age to assess for risk of autism spectrum disorders. Since the test authors wanted to maximize sensitivity of the test, (the number of children with a disorder who are identified by screening), there is a high false positive rate, with sensitivity at 87% and specificity at 99%. Therefore, not every child who scores in the at-risk category will be diagnosed with autism (Robins et al., 1999). Children who fail more than three items on the *M-CHAT,* or who fail two or more of the six critical items, are recommended for diagnostic evaluation for autism.

Reliability of the *M-CHAT.* According to the manual, the reliability of the *M-CHAT* was assessed by determining Cronbach's alpha for all items, which was judged to be high (.85). Concurrent validity studies used the *Bayley Scales of Infant and Toddler Development*, the *Vineland Adaptive Behavior Scale* and the *Childhood Autism Rating Scale*. The results showed a significant difference in the performance of the children with autism on all items of the *M-CHAT*, compared to typically developing children, with the exception of two items: "Does your child walk?" and "Does your child enjoy being swung, bounced on your knee, etc?".

Checklist of Children's Gestures. The *Checklist of Children's Gestures* is a newly devised instrument that assesses the gestures that young children use, plus the child's ability to imitate each gesture (Brann, 2009). The *Checklist of Children's Gestures* uses a parent report format, a method that has been shown to be a reliable means of assessing children's behaviors (e.g., Fenson, Dale, Resnick, Bates, Thal, & Pethick, 1994), including language skills. Gesture items were developed from the relevant research literature on the acquisition of gestures and from the researcher's clinical experience with children with language disorders. In addition, parents reviewed earlier iterations of the checklist and provided suggestions for more gestures. These gestures were then added to the *Checklist of Children's Gestures* (Appendix A). After several iterations, the final version of the *Checklist of Children's Gestures* consisted of 18

dichotomous items in a checklist format. The scoring is dichotomous, with the item scored "1" if the parent reports that their child spontaneously uses the gesture, and "0" if the parent reports that the child does not use the gesture.

The domain of imitation of gestures was included in the *Checklist of Children's Gestures* since imitation is one way that infants learn complex behavior, including some aspects of language (Melzoff & Decety, 2003). Although pilot testing (Brann, 2009) showed no significant difference between groups on this domain, the imitation of gestures domain was included on the *Checklist of Children's Gestures* so that parents have items to check ("imitates") if their child does not currently produce any gestures spontaneously. The rationale for this is so that parents do not feel that their child is below his peers if he or she is not using gestures at this time (Fenson et al., 1994). Therefore, since the results of the pilot study indicated there was no significant difference between groups on the imitation domain, and moreover, since the present study was interested in spontaneous gestures that children use, the imitation domain was not analyzed for this study.

The 18 gesture items were categorized according to Bruner's categories of behavior regulation (requesting objects or actions or protesting), joint attention (commenting and requesting information), and social interaction (using representational gestures, attention seeking, and social games):

Behavior regulation

Points to request
Holds hand up for stop
Pulls adult's hand indicate want
Stomps feet when mad
Pushes food away
Holds arms up picked up
Finger to lips "quiet"
Shakes head "no"

Points to indicate me/ my turn
Nods head for "yes"

Joint attention

Shrugs shoulders
Points to call attention
Holds up objects to show
Pushes food away
Holds up fingers for age

Social interaction.

Waves hand for "Hi"
Gives high five
Claps hands for "Yay"!
Moves hands up/down

The validity and reliability of the *Checklist of Children's Gestures* were determined through pilot testing with 27 participants on an earlier iteration of the test, including nine gesture items (Brann, 2009). These participants were placed into three groups based on their scores on the *Rossetti Infant-Toddler Language Scale*, a language test that determines eligibility for early intervention services in Illinois. The three groups were: participants with typically developing language skills (TD), children with specific language impairment (SLI), and children who were diagnosed with autism by their pediatricians. As the mean age for the group with ASD was older than the group with TD and SLI, an analysis of co-variance (ANCOVA) was conducted, with age as the co-covariate. The results showed that the groups differed significantly ($p < .05$) on the use of spontaneous gestures. Pair wise comparisons between groups on the spontaneous gesture variable with Fisher's LSD showed that children with SLI and children with typically developing language were reported to use more gestures than the group with autism ($p<.05$). No significant differences were found between the group with typically developing language skills and the group with SLI. An item analysis showed that the group with autism differed from the SLI and

typically developing groups on three gestures: head shake for "no", head nod for "yes", and waving to say "hi". No significant group difference was found on the imitated gestures domain (p>.10).

Next, an analysis of the pilot data was conducted with Facets, an approach to analyzing rating scale data to rate an individual's performance on a task, or to measure specific traits, which in this study was a participant's use of gestures. Facet one was the 27 participants, facet two was the three groups, and facet three was the nine spontaneous gestures items. I used a many-facet Rasch measurement model of dichotomous data (Linacre, 1992) and analyzed it with the Minifac 3.66.0 student version software (Linacre, 2009). The results indicated that the *Checklist of Children's Gestures* may need more items to increase the variability along the scale, according to the vertical map. One item ("points to show something to call my attention to it or to ask for it") showed overfit, which indicated less variability in the data than the Rasch model predicted. Overfit may reflect dependency in the data (Bond & Fox, 2007). One possible explanation for overfit of this item is that the item asks two separate questions, since the item contains the conditional word *or*. The *Checklist of Children's Gestures* was then revised, based on the Facet analysis, and another parent focus group was held to determine parents' opinion of the wording of this question, which was positive.

Validity. Previous iterations of the *Checklist of Children's Gestures* were assessed by the true score model to assess the underlying construct of gestures. Results indicated that one item had five negative correlations on the Inter-item covariance matrix, which indicated that this item did not measure the underlying construct of gestures. The item was removed to improve the unidimensionality of the test.

Content validity encompasses face validity, or the extent to which a test contains items that appear to measure what it intends to measure, and technical validity, i.e., how clearly the items are stated to the examinees. Two speech-language pathologists reviewed the *Checklist of Children's Gestures* items and agreed that the items adequately measured the construct of gestures, meeting the requirement for face validity. For technical validity, a parent focus group was held prior to the pilot study, as previously noted, and subsequent changes were made to the survey, incorporating the parent suggestions.

Reliability. Reliability testing of the *Checklist of Children's Gestures* was determined by calculating the real item separation reliability in Rasch, which is similar to Cronbach's coefficient alpha. Since it was .94, this was an indication that the test may be considered to have good reliability.

IV. RESULTS

This study investigated four research questions. First, what is the developmental pattern of gesture use in children with typical development? Second, what is the developmental pattern of gesture use in children who are at risk for autism? The third research question asks how gestures are related to demographic measures. Fourth, controlling for demographic measures, how much variance in language scores can be explained by *M-CHAT* scores and gesture ability?

Descriptive Statistics

Descriptive statistics for the demographic variables and the 18 items in the *Checklist of Children's Gestures* are in Table I. Age was an ordinal variable: participants were either 24 or 36 months of age. Other demographic variables were: gender, ethnicity (Caucasian, African-American, Hispanic, Asian, or "other"), language environment (English speaking versus bilingual), ethnicity, and the educational level of the primary caregiver. Educational level was defined by five category levels: graduate degree, 4 years of college, one to three years of college, high school graduate, or 10 to 11 years of high school. Family socioeconomic status (SES) was defined by four levels: over $100,000, between $50,000 and $100,000, below $50,000, or on public assistance.

Table I

Descriptive Statistics

Variable	n	percentage
Gender		
Female	78	43.6
Male	88	49.2
Missing data	13	7.3
Age		
24 months	97	54.2
36 months	82	45.8
Language Environment		
English only	122	68.2
Bilingual	44	24.6
Missing data	13	7.3
Ethnicity		
Caucasian	68	38.0
African American	54	30.2
Hispanic	25	14.0
Other (multi-racial)	6	8.9
Missing data	16	8.9
Highest Educational level		
Graduate degree	64	35.8
4 years college	44	24.6
1-3 years college	51	28.5
High school graduate	8	4.5
7-9 years of school	0	0
10-11 years school	6	3.4
Missing data	6	3.4
Speech-language therapy status		
None reported by parents	169	94.4
Receiving speech therapy	6	3.4
Scheduled for speech		
evaluation	1	.6
Referred for speech	1	.6
Missing data	2	1.1
Family income		
Over 100K	32	17.9
Over 50K	69	38.5
Below 50K	45	25.1
Public assistance	24	13.4
Missing data	9	5.0

The frequency count of the 18 items on the *Checklist of Children's Gestures*, using the Total gesture score (total number of gestures parent reported), is listed in Table II. Two gesture items, item 10 ("My child holds up objects to show me") and item 12 ("My child pushes food away when he/she does not want it"), had a frequency count of 179, indicating that all 179 participants were reported to use these gestures. Although both items were included in the Rasch analysis, since the research question was to determine the pattern of gesture use in participants, these items were deleted in the regression analyses for lack of variation.

Additionally, several other items had low frequency of absent responses: only two out of the 179 participants did not use the gesture of raising their arms up, and only three participants did not shake their head for "no", point to request objects, or claps their hands for "Yay". These items were retained in the analyses, due to the fact that the goal was to identify which participants used these gestures.

Table II

Percentage of Participants Who Used Each Gesture

Gesture Item	Percent correct for 2-year-olds	Percentage correct for 3-year-olds
Pushes food away	100	100
Holds up objects to show	100	100
Holds arms up to be picked up	99.0	98.8
Shakes head "no"	97.9	98.8
Points to request	96.9	100
Claps hands for Yay!	96.9	100
Points to call attention	96.9	98.8
Gives high five	96.9	97.6
Waves hand for "Hi"	95.9	94.0
Pulls adult's hand indicate want	95.9	100
Moves hands up/down	87.6	94.0
Nods head for yes	82.5	96.4
Stomps feet when mad	82.5	86.7
Shrugs shoulders	78.4	90.4
Finger to lips quiet	73.2	88.0
Points to indicate *me, mine*	62.9	86.7
Holds hand up for *stop*	50.5	79.5
Holds up fingers for age	27.8	78.3

Correlation Analyses

To determine the strength and direction of the relationship between the sixteen gestures with variance over 0.0, one-tailed correlation analyses were conducted for the whole sample. Since there are two age levels in the sample, age was controlled for. Pearson product moment correlations (Table III), were computed. High correlations were found between "points to something to call attention to it" and "points to request something" (r=.57, p<.01), "pulls adult's hand to indicate something that he wants" and "points to request something" (r=.56, p<.01), and (r=.49, *p*<.01). Moderate correlations were noted between "holds hand up for 'stop' and "shrugs shoulders or holds hands or arms up to say "where is it" (r=.38, *p*<.01), and *"*waves for "Hi" and "shakes head for 'no'" (r=.37, *p*<.01). The lowest significant correlations were between "finger to lips for 'quiet'" and "points to request something*" (r=.13, p<.05), and* "finger to lips for 'quiet'" and "claps hands for 'Yay'" (r=.13*, p*<.05). In addition, low, significant correlations were noted between "waves for 'Hi'" and "holds up fingers for age" (*r*=.13, *p*<.05) and "holds up fingers for age" and holds his or her arms up to ask to be picked up" (*r*=.14, *p*<.05).

Table III

Correlation between Gestures

	waves "Hi"	shakes head "no"	points request	shrugs	nods "yes"	shh" quiet	fingers for age	arms up	me/my turn	points: attention	high 5	hands up-down	pulls adult's hand	stop	stomps	claps "Yay"
Waves "Hi"	__	.37**	.18*	.26**	.09	.16*	.13*	-.03	.11	.32**	-.04	.10	.15*	.29**	.20*	.18*
Shakes head "no"	.37**	___	-.02	.30**	.23**	.04	.04	-.01	.22*	-.02	-.02	-.05	-.03	.08	.07	-.02
Points-request	.18*	-.02	___	.16*	-.08	.13*	.09	--.01	-.01	.57**	-.03	-.06	.56**	.15*	.06	-.03
Shrugs shoulders	.26*	.30**	.16*	___	.25**	.21*	.23**	.10	.29**	.23**	.01	.05	.01	.38**	.06	.04
Nods "yes"	.09	.23**	-.08	.25**	___	.24**	.09	-.04	.27**	.05	.15*	.17*	-.09	.12	.03	.21*
shh" quiet	.16*	.04	.13*	.21*	.24**	___	.12	-.05	.27**	.20*	.26**	.11	.09	.36**	.01	.13*
Fingers for age	.13*	.04	.09	.23**	.09	.12	____	.14*	.25**	.15*	.11	.15*	.01	.23**	.03	.09
arms up	-.03	-.01	-.01	.10	-.04	-.05	.14*	__	-.07	-.02	-.02	.15*	-.02	.15*	.11	-.01
me/my turn	.11	.22*	-.01	.29**	.27**	.27**	.25**	-.07	____	.16*	.13*	.13*	.14*	.30**	-.02	-.01
Points-attention	.32**	-.02	.57**	.23**	.05	.20*	.15*	-.02	.16*	__	-.03	-.07	.49**	.20*	.15*	-.03
High five	-.04	-.02	-.03	.01	.15*	.26**	.11	-.02	.13*	-.03	__	.17*	-.03	.23**	.22*	-.03
Hands up/down	.10	-.05	-.06	.05	.17*	.11	.15*	.15*	.13*	.07*	.17*	___	.07	.13*	.24**	.24**
Pulls adult's hand	.15*	-.03	.56**	.01	-.09	.09	.01	-.02	.14*	.49**	-.03	.07	__	.09	.14*	-.04
Stop!	.29**	.08	.15*	.38**	.12	.36**	.23**	.15*	.29**	.20*	.23**	.13*	.09	__	.24*	-.05
Stomps feet	.20*	.07	.06	.06	.03	.01	.03	.11	-.03	.15*	.22*	.24**	.14*	.24**	__	.18*
Claps "Yay"	.18*	-.02	-.03	.04	.21*	.13*	.09	-.01	-.01	-.03	-.03	.24**	-.04	-.05	.18*	__

*p<.05

**p<.01 for 1 tailed test

Factor Analysis

Exploratory factor analysis (EFA) was performed to determine if there were different dimensions of gesture groups in the sample, since the literature reports different clusters of gesture functions: behavior regulation, joint attention, and social interaction. Grouping of these gesture types may be more easily seen in EFA than in a frequency table.

Initially, exploratory factor analysis was run with all 18 gesture items. However, as shown in the descriptive analyses, the correlation matrix showed that items 10 and 12 had zero variance. Items 10 and 12 were then deleted and the factor analysis was performed with the remaining16 gesture items.

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was .666. Values close to 1.0 indicate that patterns of correlations are relatively compact; therefore, the KMO measure of .666 falls into the acceptable range. Bartlett's test of sphericity was significant ($p<0.001$).

Six factors were extracted in the Principal Component Analysis (PCA) with Varimax rotation, (Table IV) with three main factors evident. Results indicated that six factors had eigenvalues larger than 1.0. The first factor contained five gestures that are often categorized as behavior regulation gestures (by requesting objects or actions or protesting) in the literature (Bruner, 1983). Also in factor one are four gestures considered to be joint attention gestures in the literature (by commenting and requesting information) and one gesture is considered a social interaction gesture (by using representational gestures, attention seeking, and social games) ("wave hi"). The first factor explains 20.44% of the variance. The second factor explained 12.21% of the variance. It showed negative loadings on two behavior regulation gestures, and negative loadings on two joint attention gestures. All four gestures showed positive loadings in the first factor. However, bipolar loadings (positive and negative) are common in the second and

third factors, and cannot be interpreted in light of the data (Kline, 1994). Together, factors one and two explain 32.65% of the variance.

A third factor showed high loadings on only three gestures: -.598 for a behavior regulation gesture ("shakes head for no"), .474 on the behavior regulation gesture ("stomps feet when mad"), and .538 on "moves hands up and down when excited". The latter is a gesture in the checklist that is considered to be a red flag for autism in the Diagnostic and Statistical Manual IV (DSM-IV). Variance that can be explained by factors three through six are in Table V.

Table IV

Principal Component Analysis

Gesture	Component					
	1	2	3	4	5	6
16. Holds hand up For "stop"	.678	.135	.056	-.176	.323	-.167
4.Shrugs shoulders	.601	.135	-.357	.037	.249	.123
9. me/my turn	.570	.238	-.236	-.325	-.063	.105
6 Shh-"quiet"	.567	.153	.030	-.329	-.252	-.090
7 Fingers age	.519	.170	.073	-.203	.183	.386
3.Points to request	.443	-.717	.024	-.066	-.045	.053
15. Pulls adult hand	.414	-.669	.139	-.045	-.114	.021
11. Points to draw Attention	.561	-.598	.015	.009	-.079	.047
5. Nods for "yes"	.436	.453	-.136	-.013	-.312	.140
2. Shakes head for "no"	.290	.211	-.598	.397	.080	-.242
14. Hands up/down	.341	.260	.538	.195	-.066	.172
17. Stomps feet	.344	.028	.474	.421	.105	-.393
1. Waves "Hi"	.474	-.102	-.244	.571	-.035	-.203
8. Arms up	.076	.077	.278	.154	.744	.264
18. Claps for "Yay"	.219	.255	.295	.443	-.462	.375
13. High 5	.255	.299	.376	-.329	-.052	-.582

Extraction Method: Principal Component Analysis.

It appeared that all 18 gestures look at the underlying construct of gestures in the factor analysis. In factor one, the highest loading gestures may be early acquired gestures, and the gestures that did not show high loadings may be later acquired gestures. Factor two showed high negative loadings on two behavior regulation and one joint attention gesture, and a high positive loading on one behavior regulation gesture. In factor three, one behavior regulation gesture was high but negative, and one was high and positive, with the third high loading gesture a social interaction gesture. Factor four showed high loadings on two gestures that are considered recognitory gestures, taught by parents: “waves for hi/bye” and “claps for “Yay”.

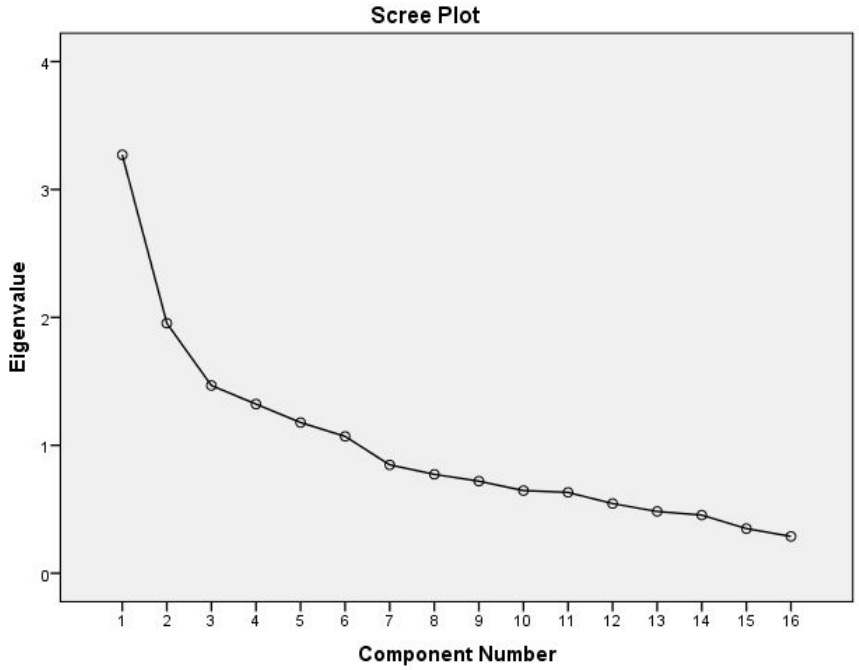
Table V

Variance of Principal Components

Component	Eigenvalue	Variance Explained	Cumulative Variance
1	3.27	20.44	20.44
2	1.95	12.21	32.65
3	1.47	9.17	41.83
4	1.32	8.26	50.09
5	1.18	7.36	57.46
6	1.07	6.68	64.14

Three main components are also shown in the graph of eigenvalues and principal components, the scree plot (Figure 1), with the "elbow" turning downward at factor three. Although this is a subjective measure of the main components, the scree plot confirms the analysis of three main factors in the data.

Figure 1



The communality measures the percent of variance in a given variable explained by all the factors together, and can be considered a measure of reliability. The communality of the 16 items before and after extraction is over .526.

To summarize, the factor analysis with 16 items that had frequency of over one revealed three main factors: the first factor contained five behavior regulation and four joint attention gestures; the second factor had negative high loadings on three gestures, two behavior regulation and one joint attention gesture; the third factor had high loadings on two behavior regulation gestures, and one gesture considered a risk factor gesture for autism in the literature. The fourth factor showed high loadings on two recognitory (parent taught) gestures.

Rasch Analysis

The second question that this study investigated was "what is the developmental pattern of gesture use in children who are typically developing?" Rasch analysis was first performed on all 18 gesture items, with all 179 participants in the sample, to determine how "easy to endorse" parents found each gesture. This analysis included participants who were typically developing, and participants who failed a screening test for autism, the *Modified Checklist for Autism in Toddlers* (M-CHAT). The first step was to check the real item and real person separation, similar to Coefficient alpha (Smith, 1999), which was .34 (Table VI). This suggested that the participants did not respond in a consistent manner across all 18 gestures items. The real item separation reliability of .94 indicated that the items created a well-defined variable, and the item separation index of 4.14 indicated that items were adequately dispersed on the scale. Next, fit statistics were examined. When the data fit the model, Outfit statistics approximate *t*-statistics, with a mean of 0.0 and a standard deviation (SD) of 1.0. The OUTFIT ZSTD for participants

(persons) had a mean of .1 and a SD of .8, indicating good fit. The mean OUTFIT ZSTD for items was .0 and the SD was 1.0, again indicating good fit.

Table VI

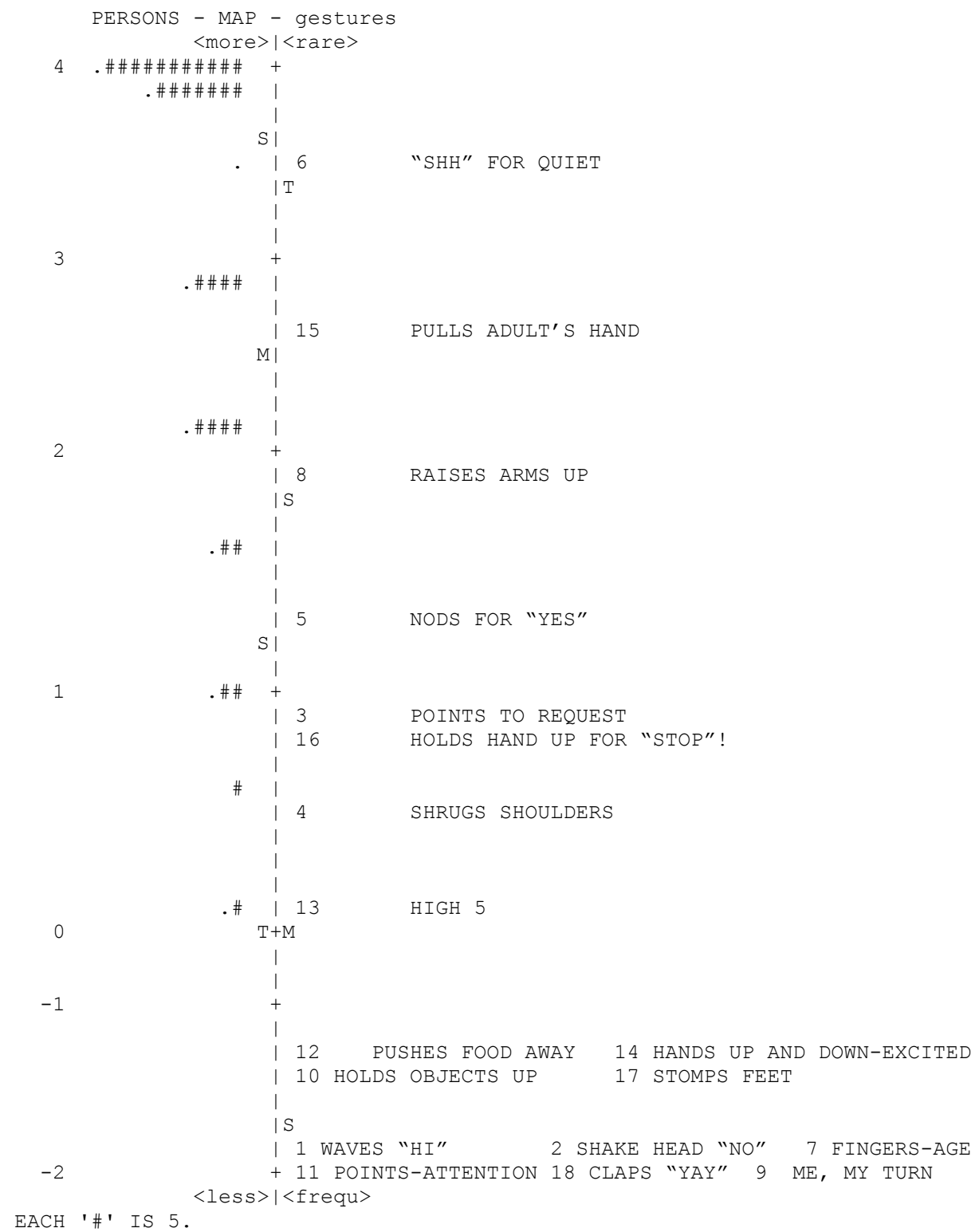
Person and Item Reliability

Persons	
Person reliability	.34
Person reliability	.44
Items	
Gesture reliability	.94
Mean ZSTD	.1
S.D.	.8
Separation	4.14

The variable map is a distribution of persons and items on a common logit metric (Smith, 1999), with the mean item difficulty set at 0.00. The mean is indicated by *M* on both sides of the vertical line, *S* represents plus or minus one standard deviation, and *T* represents plus or minus two standard deviations. Items are listed on the right side of the variable map (Figure 2) in order of difficulty, with "rare" the most difficult gesture for parents to endorse and "frequent" the easiest gestures to endorse. The most difficult gesture for parents to endorse was Item 6 ("fingers to lips for 'quiet'"), shown by "rare" under gestures on the right hand side of the map. The easiest for parents to endorse, shown at "frequent", were items 11 ("points to draw attention to an object"), 18 ("claps hands for 'Yay'"), and 9 ("child points to himself for 'me', or 'my turn'"). One difference between the frequency of gestures (Table II) and the Rasch analyses (Figures 2 and 3) is that the gesture items were now placed on a ratio scale, whereas in the frequency table, the Total gesture scores were on an ordinal scale. Therefore, the order of the gestures differed in the two analyses.

Participants are located on the left side of the variable map, and listed by their ability. Those with higher ability are located at the top of the map, under “more”, and those participants with lower ability are located at the bottom of the variable map, under “less”. When a participant aligns with an item, that participant is predicted to have a 50% chance of succeeding on that item. On the left side of the map, many participants are located at measure 4, but there are no gesture items at their ability level, indicating that more difficult gesture items are needed. Similarly, several participants are at measure 3, but there are no gestures at their ability level.

Figure 2
Variable map: All Participants

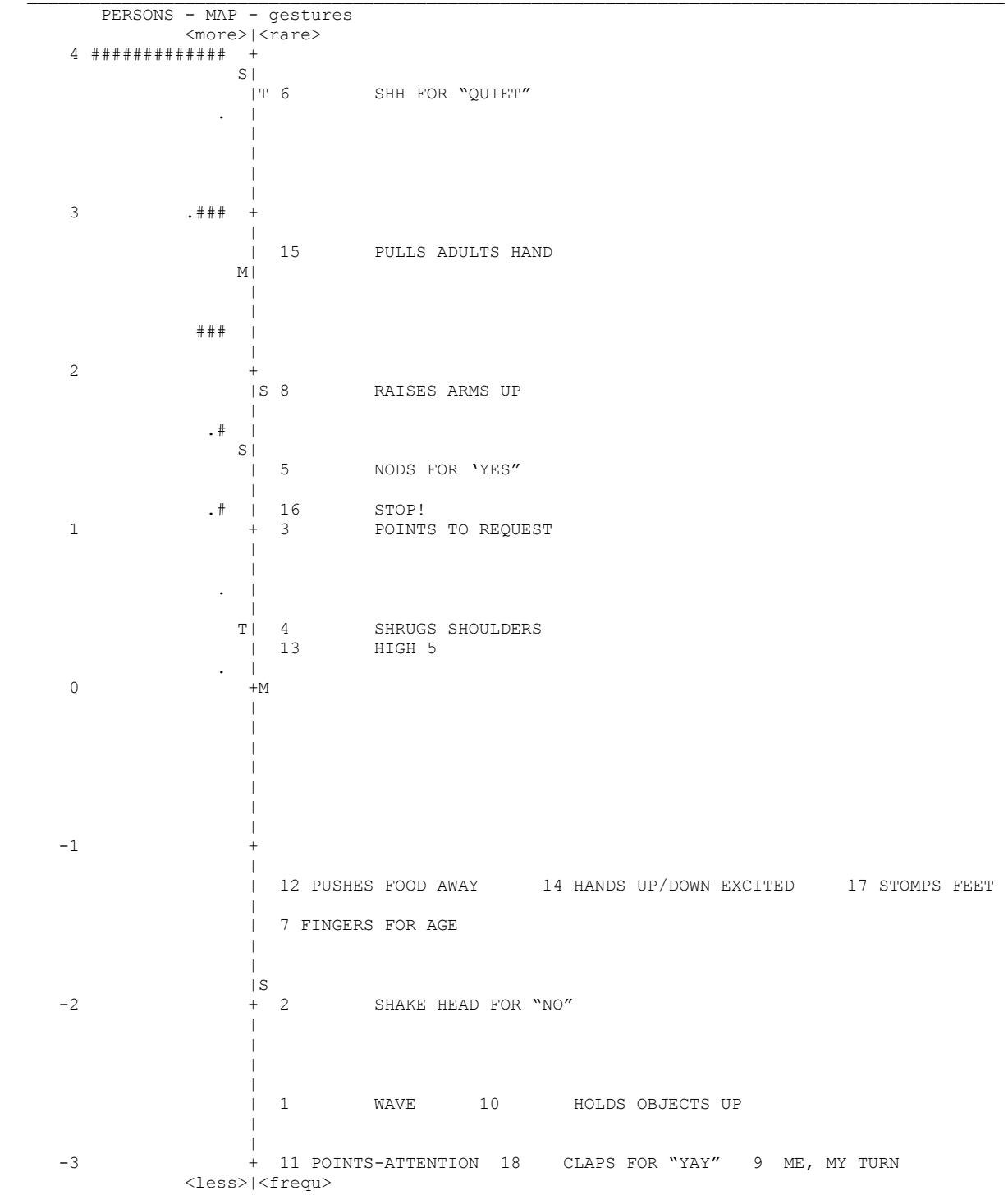


Six of the seven highest gestures on the variable map also showed high positive loadings on factor one of the factor analysis; the only gesture of the top seven that did not have high loadings on factor one was "Raises arms up". Since factor one consisted of high loadings on five behavior regulation and four joint attention gestures, one possible explanation is that this is consistent with the developmental order of gesture acquisition.

Six gestures were on the "easiest to endorse" end of the variable map. Four of these gestures also had high loadings on factor one, and two had low loadings on factor one.

Participants who passed *M-CHAT*. The next analysis included only the participants who passed the *M-CHAT* screening test for autism (n= 165). The 14 participants who failed the *M-CHAT* were excluded from this analysis. The real person separation reliability was .33, suggesting that participants did not respond to the items in the *Checklist of Children's Gestures* in a consistent manner. Outfit statistics showed a mean of .1 and an SD of .7, both lower than expected values. The real item separation reliability of .92 indicates that the items create a well-defined variable. The mean item OUTFIT ZSTD of -.1 and the SD was .8, lower than expected. The variable map (Figure 3) showed that the most difficult gesture for parents in this sample to endorse was item 6 ("Shh for quiet"), and the next most difficult was item 15 ("Pulls adult's hand"), which is similar to the results for the entire sample of all 179 participants. The easiest items for parents to endorse were items 11 ("Points to draw attention to an object"), 18 ("Claps for 'Yay'"), and 9 ("Child points to himself for me, or my turn").

Figure 3
Variable map: Participants who passed M-CHAT.



Gestures in Children Who Are at Risk for Autism

The next question was which gestures the participants who failed a screening test for autism (*M-CHAT*) were reported to use. Unfortunately, Rasch analysis could not be performed on the 14 participants who failed the *M-CHAT* due to the small sample size. Instead, descriptive statistics (Table VII) were performed on the items that the participants who passed the *M-CHAT* used, vs. the items that the participants who failed the *M-CHAT* used.

Table VII

Percentage of Participants Who Passed Gesture Items

Gesture Item (n=14)	Passed *M-CHAT* (n=164)*	Failed *M-CHAT*
Hold up	100	100
Push away	100	100
Points for attention	99.4	78.6
Shakes head for "no"	99.4	85.7
Arms up	98.8	100
Points to request	98.8	82.9
Pulls adult's hand	98.2	92.9
Claps for "Yay"	98.2	100.0
High 5	97.6	92.9
Wave "Hi"	95.7	85.7
Nods for "yes"	91.5	57.1
Hands up/down	90.0	85.7
Shrugs shoulders	86.0	57.1
Stomps feet	84.1	85.7
Shh-quiet	82.9	50.0
Me/my turn	76.8	35.7
Stop	65.9	42.9
Fingers for age	53.0	35.7
Mean	16.18	13.79
SD	1.89	3.17

* data missing for one participant

According to the frequency analysis (Table VII), some trends were apparent: the participants who passed the *M-CHAT* and the participants who failed the *M-CHAT* differed on the following gestures items: "points to self for me/my turn" (76.8% for those who passed the *M-CHAT*, 35.7% for those who failed); "Nods head for "yes" (91.5% for those who passed *M-CHAT*, 57.1% for those who failed; and "places fingers to lips for "Shh-quiet" (82.9% for those who passed, 50% for those who failed). However, these differences may not be statistically significant.

The variable map (Figure 3) for all participants showed that many had high ability, or used more gestures, shown by all 179 participants falling above the mean for all gestures. There were no participants at the lesser ability end of the map. This may be an indication that many of the gestures were easy for all participants, suggesting that the participants were too old for showing a developmental change in the gestures measured in the *Checklist of Children's Gestures.* Therefore, an analysis of the two age levels was conducted next.

Age Groups

Since there were two age groups in the sample, analysis of variance (ANOVA) was conducted between the two and three year olds to compare the group means on gestures. The Total gesture score was the dependent variable and the independent variable was age. Levene's test was significant ($p<.05$), therefore the assumption of homogeneity of variances was violated. One solution would be to transform the data. Therefore, these results are reported with caution (Table VIII). It appeared that there was a significant difference between the two age groups on Total gesture scores: ($F(1,177)=33.11$, $p<.05$), critical value=3.90, $p<.05$.

Table VIII

One Way ANOVA of Age Groups for Gestures

	Age 2 (n=97)	Age 3 (n=82)
Mean	13.24	14.90
SD	2.08	1.74

Next, the participants' *M-CHAT* status (pass or fail) was controlled for. Results showed a significant difference between the two age groups on the Total gesture score ($F(1,175)=18.66$ $p<.05$). In addition the partial eta squared of .16 indicates there was a weak relationship between the *M-CHAT* scores and the age groups. Since the ANOVA did not show which gesture items showed a significant difference between the two age groups, the next step was to conduct a chi-square test to answer this question.

Chi Square Analysis of Gestures

An Independence Samples chi-square analysis was performed between the two age groups on the frequency of the 16 gestures that had variance over zero. Chi-square tests can be used to examine the difference between frequencies. The assumption of independence of samples was met, but the assumption of expected frequencies over five in each cell was not met for seven of the gestures. One solution would be to collect more data before conducting a chi-square analysis on the gestures (Fields, 2009). The gestures that did not meet the assumption of expected frequencies were not reported here (Table IX).

Table IX

Chi-square Test for Age Effects in Gesture Use

Gesture	Chi-square	2 year olds-percentage	3 year olds-percentage
Fingers for age	48.56*	27.8	80.2
Stop	16.77*	51.0	80.5
Me/my turn	12.89*	62.9	86.6
Nods for "yes"	8.61*	82.5	96.3
Shh for "quiet"	7.08*	73.2	89.0
Shrugs shoulders	4.63*	78.4	90.2
Hands up/down	2.04	87.6	93.9
Stomps feet	1.38	82.5	88.8

*p<.05

Correlation

Additional correlation analyses were employed to check the assumptions of regression for the next analyses, stepwise and hierarchical regression. Predictor variables cannot be highly correlated (correlations above .80 or.90.), or multicollinearity may be present. Since all correlations were low or moderate, we concluded that no multicollinearity existed among the demographic variables. Therefore, one of the assumptions of regression was met.

Pearson's correlation coefficients were calculated for the 16 items that had variance over .00 according to the descriptive statistics analysis, and the language measure, *Bayley* scaled scores. The two items with variance of 0.00 were deleted from the correlation and regression analyses. The results indicated that the total gesture scores correlated with receptive language scaled scores on the *Bayley* (r=.235, p<.01), expressive language scaled scores (r=.295, p<.01)

and the sum of language scaled scores (both receptive and expressive language scaled scores (r=.283, $p<.01$). These are all considered low correlations, so no multicollinearity was present. Not surprisingly, high correlations were found between the receptive and expressive scaled scores on the *Bayley* (r=.716, $p<.01$).

Partial correlations were run, controlling for age, since there are two different age levels in the sample. Results showed that when the effects of age are controlled for, total gesture scores were correlated with receptive language scaled scores (r=.234, $p<.01$), expressive language scores (r=.225, $p<.01$), and sum of language scores (r=.244, $p<.01$). These are all considered low correlations, indicating no change in the correlations when age was controlled for. High correlations were found between the receptive and expressive scaled scores on the *Bayley* (r=.725, $p<.01$).

Pearson's correlations (Table X), showed that for the demographic variables, the highest correlation was between the total number of gestures and age ($r=.40$, $p<.01$), and the lowest correlation was between gender and educational level ($r=.22$, not significant).

Table X

Pearson's Correlation Coefficients for Demographic Variables

	Gender	Age	Language environment	Education level	SES
Gender	__	.052	-.038	.22	.067
Age	.052	__	.156*	-.076	.100
Language environment	-.038	.156*	__	-.039	-.080
Education Level	.022	-.76	-.039	__	-.055
SES	.067	.100	-.80	-.055	__
Gesture Score	.085	.401**	.056	-.116	.153*

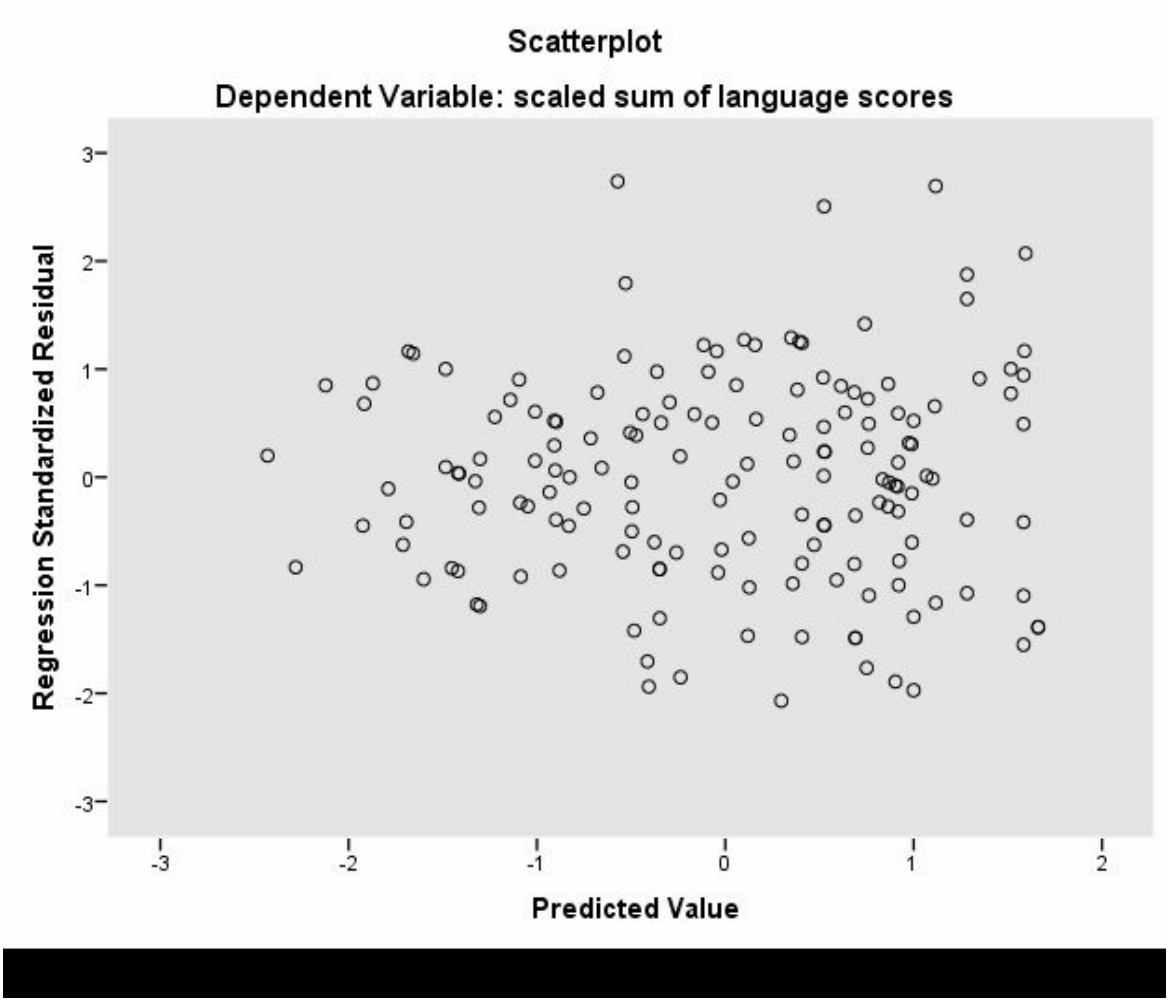
*$p<.05$
**$p<.01$

Assumptions of Regression

Statistical methods were employed to check the other assumptions of regression for the stepwise and hierarchical regression analyses. Collinearity statistics were conducted, and the variance inflation factor (VIF) was under 2.16, indicating there is not a strong relationship between the predictors. The reciprocal of VIF is the tolerance, which should be more than .02, and in these regression analyses, all tolerance levels were over .46. Therefore, the conclusion was that there was no collinearity within the data. In the stepwise regression analysis, the Durbin-Watson was 1.86, close to the desired value of 2, so the assumption of independent errors was met.

The assumption of homoscedasticity (constant variance) was checked for the hierarchical regression analysis. The plot of *Z*RESID sand ZPRED (Figure 4) showed the standardized residuals are randomly distributed, without funneling or a curvilinear pattern. Therefore, the assumption of homoscedasticity was met.

Figure 4



Regression Analyses

The third research question was the relationship among gesture use and the demographic measures of gender, language environment, age, ethnicity, parental education level, and SES. Two regression analyses were conducted to determine the nature of the relationships among the variables. The stepwise method of entry was used, in which the computer selects variables based on their semi-partial correlation with the dependent variable. The first predictor entered was the one with the highest correlation with the dependent variable.

The dependent variable was the Gesture Ability Measure on the *Checklist of Children's Gesture,* and not the total gesture score. The rationale was that the total gesture score was on an ordinal scale and the Rasch analysis placed the gesture scores on a ratio scale. Therefore, the gesture ability measure was used in both regression analyses. The demographic variables of gender, educational level of parents, SES, language environment, and ethnicity were the independent variables. Missing demographic values were deleted from the analysis. The demographic variables are categorical variables, therefore they were dummy coded for the regression analyses. A reference variable was selected based on the group with the highest frequency. For gender, the reference group was male, based on the higher frequency count in this group. Similarly, the reference category for age was two; for ethnicity, the reference category was Caucasian, based on a higher frequency in that category. Originally, there were four categories of SES: over 100K, over 50K, below 50K, and on public assistance. These were collapsed into low (public assistance), medium (below 50K and over 50K), and high SES (over 100K), with low SES chosen as the reference category.

For parental education level, there were six categories (graduate degree, 4 years of college, one to three years of college, high school graduate, 10-11 years of school, and seven to

nine years of school). These were collapsed into 3 levels: high (graduate degree and four years of college), medium (high school graduate and one to three years of college), and low (10-11 years of school and seven to nine years of school); the high education level was chosen as the reference category, based on the highest frequency of this category. The unstandardized regression coefficient represented the difference between the group means for the reference variable and the other group.

Results indicated that age alone explained 18.5% of variance in Gesture Ability Measure scores at a significant level ($p<.01$). When the SES category of low vs. high SES was added, it explained another 2.3% of the variance ($p<.05$). All together, the demographic variables of age and SES (low vs. high) accounted for 20% of the variance ($p<.05$) in Gesture Ability Measure on the *Checklist of Children's Gestures*, which is considered a high amount of variance. None of the other variables (education, gender) explained significant variance.

The analysis of variance table (ANOVA) in the regression output showed an indication of the preferred model, model one (age), which had a higher *F*-ratio ($F(1,159)=36.064$, $p<.001$) than model two (SES). This was an indication that age was a better predictor of Gesture Ability Measure of the *Checklist of Children's Gestures* than SES.

Table XI

Stepwise Regression Summary for Total Gestures and Demographic Variables (n=161)

Predictor	*B*	*SE B*	*β*
Model 1			
Constant	2.57	.16	
Age	1.46	.24	.43**
Model 2			
Constant	2.52	.16	
Age	1.28	.25	.38**
Low vs. high SES	.72	.33	.16*

Note. B = unstandardized regression coefficient; *SEB*= standard error of *B; β* = standardized regression coefficient. *$p<.05$ **$p<.001$

The co-efficient table (Table XI) showed that age and SES made a significant contribution to the model. As noted, age and SES were recoded with age two as the reference category for age, and low SES as the reference category for SES. Therefore, the unstandardized regression coefficient represents the difference between group means for ages two and three years of age, and low and high SES on the dependent variable of Gesture Ability Measure on the *Checklist of Children's Gestures.* Specifically, three year olds would score 1.46 points higher than two year olds on the Gesture Ability Measure. For SES, a participant of high SES would score .72 points higher on the Gesture Ability Measure than a participant from low SES.

In summary, the stepwise regression analysis showed a significant difference between the two age groups and SES levels of participants on Gesture Ability Measure on the *Checklist of Children's Gestures*. For example, for model one, if a participant is two years of age and receives a Gesture Ability Measure of 5 on the *Checklist of Children's Gestures*, the predicted score for a participant three years of age would be 6.46, according to the model. In model two,

if a participant at a low SES level scored a Gesture Ability Measure of 5, the predicted score for a participant from a high SES level would be 5.72. According to both model one and two, age and SES were significant predictors of the outcome and made a unique and positive contribution to estimating the Gesture Ability Measure on the *Checklist of Children's Gestures*.

Hierarchical Regression

The fourth research question concerned how much of the variance in language scores could be explained by *M-CHAT* status and Gesture Ability Measure, controlling for demographic variables. The hierarchical method of regression was used for this analysis, since it allows the researcher to decide the order that the variables were entered, based on prior research. This method was appropriate for this analysis, since we can see the predictive value of a new variable on the outcome, and known predictors were held constant. Demographic variables (age, gender, language environment, ethnicity, educational level, and SES) were entered in the first block to control their impact on the dependent variable, the sum of language scaled scores on the *Bayley Scales of Infant and Toddler Development*. The second block consisted of *M-CHAT* status, and the third block was the Gesture Ability Measure from the *Checklist of Children's Gestures*. The rationale for this order of entry was to see how much of the variance in language could be explained by the Gesture Ability Measure, controlling for demographic variables and *M-CHAT* status.

Demographic variables (age, gender, language environment, ethnicity, educational level, and SES) and *M-CHAT* status were dummy coded in the stepwise regression, and the reference groups for these categorical variables remained the same in the hierarchical regression. Demographic variables alone, entered in block one, explained 38.9% of the variance, (p<.001) in the sum of language scaled scores on the *Bayley Scales of Infant and Toddler Development*. The

addition of *M-CHAT* status was entered into the second block because it was hypothesized that *M-CHAT* status would be related to the sum of language scaled scores on the *Bayley*. *M-CHAT* status accounted for an additional 1.6% of the variance in language scores, however this was not at a significant level. The third block, the addition of Gesture Ability Measure, added an additional 2.3% of the variance ($p<.05$). All three predictor variables, demographic variables, *M-CHAT* status and Gesture Ability Measure, accounted for 42.8% of the variance in the sum of language scaled scores on the *Bayley Scales of Infant and Toddler Development*.

In examining the ANOVA table of the regression output, model one, with demographic variables as predictors alone, and model two, with *M-CHAT* status alone, had similar *F*-ratios. However, model one had a slightly larger *F*-ratio ($F(10,148)=9.44$, $p<.05$), indicating that this was the best model.

As noted, all categorical variables were recoded, so the unstandardized beta values (Table XII) in the co-efficient table represent the difference between the group means for the reference category and the comparison category. The beta value is converted to a *t*-statistic, and tests whether the difference in group means is 0. The following group means differed significantly on the dependent variable of sum of language scaled scores on the *Bayley Scales of Infant and Toddler Development*: gender (male was the reference group); ethnicity (Caucasian was the reference group); parental educational level (high education level was the reference group); and Gesture Ability Measure. Age, language environment (English only), socioeconomic status, and *M-CHAT* status were not significant in the hierarchical regressions.

The results of Table XII were interpreted as follows: in model one, if a male participant scored a sum of language scaled score of 10 on the *Bayley*, a female participant would have a score of 12.36 ($B = 2.36$ points higher than males, the reference group). We could interpret the

difference between the ethnic groups as follows: if a participant who is Caucasian (the reference group) had a sum of language scaled score of 10 on the *Bayley,* an African American participant would score 5.55, a Hispanic participant would score 6.63, and a biracial participant would score 6.80. For education level, if a participant from a high education level received a sum of language scaled score of 10 on the *Bayley*, a participant whose primary caregiver had a medium education level would score a 7.21, and a participant from a low education level would receive a score of 4.7. Similar results were noted in model two.

Table XII

Hierarchical Multiple Regression for Sum of Language Scaled Scores (n =159)

Predictor	*B*	*SE B*	*β*
Block 1			
Constant	23.12	1.13	
Male	2.36	.72	.21**
English Only	.64	1.00	.05
Age 2	.73	.81	.06
Ethnicity			
AA	-4.45	1.05	-.37**
Hispanic	-3.37	1.25	-.21*
Biracial	-3.20	1.35	-.17*
Education			
High vs. med	-2.79	.96	-.23*
High vs. low	-5.30	2.39	-.15*
SES			
Low vs. med	.60	1.00	.05
Low vs. high	1.35	1.39	.09
Block 2			
Constant	20.72	1.66	
Male	2.28	.72	.20*
English only	.41	1.00	.03
Age 2	.76	.80	.07
Ethnicity			
AA	-4.39	1.04	-.37**
Hispanic	-3.17	1.24	-.20*
Biracial	-2.96	1.35	-.16*
Education			
High vs. med	-2.44	.97	-.20*
High vs. low	-5.48	2.37	-.15*
SES			
Low vs. med	.56	.99	.05
Low vs. high	1.16	1. 38	.08
M-CHAT status	2.59	1.32	.13

Table XII (continued)

Hierarchical Multiple Regression for Sum of Language Scaled Scores (n =159)

Block 3

Constant	19.75	1.68	
Male	2.17	.71	.19*
English only	.29	.98	.02
Age 2	-.02	.85	-.00
Ethnicity			
AA	-4.24	1.02	-.36**
Hispanic	-3.05	1.22	.19*
Other	-2.63	1.33	.14*
Education			
High vs.med	-2.45	.96	-.20*
High vs. low	-5.48	2.33	-.15*
SES			
Low vs. med	.67	.98	.06
Low vs. high	.94	1.36	.06
M-CHAT Status	1.91	1.33	.10
Gesture Ability Measure	.59	.24	.18*

Note. B = unstandardized regression coefficient; SEB= standard error of *B; β* = standardized regression coefficient

*p <.05

**p <.001

The results of model three showed that when demographic variables and *M-CHAT* status were controlled for, Gesture Ability Measure made a significant, positive contribution to predicting the sum of language scaled scores on the *Bayley.*

Qualitative Analysis

Qualitative analysis of the two open-ended questions on the *Checklist of Children's Gestures* ("Did we leave out any gestures that your child makes?" and "When your child uses these gestures, what do they communicate?") revealed the following:

Baby Signs. Fifteen parents reported their children learned sign language to communicate. The most frequent signs reported by parents were "please", "more", and "all done". One parent reported that her child learned sign language and used the signs to express himself, but no longer used the signs since he now said the words.

New Gestures. Overall, parents and wrote in a total of 29 gestures, with an explanation as to when their child uses them solve the gestures. A few gestures were redundant with existing gestures in the *Checklist of Children's Gestures*. In these cases, the parents' response to that gesture item was verified to ensure that they reported that their child used that gesture.

Several distinct categories of gestures emerged. Parents reported sensory gestures (child covers eye, ears, or plugs nose). Parents reported that their child used these gestures when they heard loud sounds or smelled something unpleasant. Many parents reported that their child used gestures to express emotion**,** e.g., "pounds fist" or "places fist in front of face" to express anger. Additionally, parents reported that their child expressed needs with gestures: "pulls on diaper" to indicate the child wanted to be changes; "smacks lips" to request a drink, "shrugs shoulders" to indicate the child was cold; rubs eyes to express being tired. A fourth category of gestures

appeared to express concepts: child holds hands up for “tall”, or makes driving motion with hands for “car”.

As far as new gestures, several parents reported that their child uses the “thumbs up” gesture when happy, excited, or accomplishes a task. One mom reported that her child imitates her doing thumbs up gesture, an indication of a recognitory gesture. The second most frequent gesture was child “placing hands across the chest” to indicate that they were mad or upset.

One concern that resulted from the qualitative analysis was that parents wrote in the gesture “my child shrugs” for “I don’t know” (two parents) or “when the child was cold” (one parent). Other parents wrote that their child holds arms up and outward for “why” or “where is it?” One concern is that item 4 lists these gestures on the checklist, but together “My child shrugs or holds up his arms to ask where is it”. It was apparent that parents reported two distinct gestures, therefore this item needs to be re-written into two separate questions.

V. DISCUSSION

A recent change in the study of early language development has been the identification of social precursors of children's first words. In particular, there has been a recent explosion of research on gesture and its relationship to the comprehension and production of oral language. The research suggests that gestures have great potential for assessment and intervention for infants and toddlers at risk for language disability. However, in spite of this research, the relationships among gesture uses, sociocultural measures and language are still not well understood. The findings and interpretations of existing studies are muddled by various definitions of gestures and conflicting coding schemes, different procedures and study designs.

The purpose of this study was to extend this research on relationships among gesture and language development in young children, through the design and evaluation of a parent report measure of early gesture. As the goal of early language assessment is to evaluate the strengths and weaknesses of communicative interactions and pre-speech language functioning in infants and toddlers (asha.org), clinicians may find it valuable to use a reliable, valid, and feasible means to assess children's gestures and to target gestures in language intervention. Researchers recommend that speech-language pathologists (SLPs) create a comprehensive profile of children's gestures during a speech-language evaluation (Crais, Watson, & Baranek, 2009). However, to adequately assess children's gestures, a new instrument was needed. This study addressed questions about the relationships among gesture use, sociocultural variables, and language development in young children, using a newly devised parent report instrument, the *Checklist of Children's Gestures* (Brann, 2009). One hundred and seventy nine participants from a variety of socioeconomic and educational backgrounds completed the *Checklist of Children's Gestures* as one of several measures in an existing study at UIC. Participants' gesture scores

were compared to their sum of language scores on the *Bayley Scales of Infant and Toddler Development.* Data were analyzed using Rasch and regression analyses to explore four questions: what is the developmental order of gestures in participants who were typically developing, compared to participants who failed the *M-CHAT*; how much variance in gestures was accounted for by demographic variable; finally, how much variance in language scores was accounted for by gesture scores, controlling for demographic variables and *M-CHAT* status.

The Developmental Pattern of Gesture Use in Children with Typical Development

The most obvious finding was that parents appeared to feel confident in reporting their child's gestures, as shown by the high number of gestures they observed in their children's repertoire. Every item on the *Checklist of Children's Gestures* was identified by many parents. Even two year olds had a mean of 13.24 and a range of 8 to 16 on the 16 gesture items with variance over zero. In fact, two gestures were used by all children ("holds objects up" and "pushes food away") confirming previous reports that these are early gestures. For example, Thal and Tobias (1991) found that infants 13-20 months hold up objects. Similarly, Crais, Douglas, and Campbell, (2004) reported that the earliest gesture for eight of their ten participants was protesting by pushing an object away. This suggests that gestures occur early and frequently, making them a useful source of information for the assessment of early communicative interactions by speech-language pathologists.

To identify how these gesture items were related to each other, factor analysis was conducted. Results suggested that two factors consisted of a mix of Bruner's gesture types based on communicative function: behavior regulation and joint attention gestures loaded on the same factor. Another factor showed high loadings on social interaction gestures, indicating that all

three of Bruner's categories were represented in the *Checklist of Children's Gestures*. This provides some evidence of construct validity in the *Checklist of Children's Gestures.*

These results are consistent with the Crais et al.'s (2004) study of intentionality between children and their parents' gestures. In their longitudinal study, they followed 12 Caucasian, monolingual, middle class children from six months through 24 months of age, over a period of 18 months. All participants had scores in the normal range on the *Bayley Scales of Infant Development-II*, in addition to parental report of their child's normal development on a developmental history form. Results indicated that for eight out of the 10 children, a behavior regulation gesture (protesting or pushing an object away), was the first gesture to develop. The next gestures to emerge were social interaction gestures, with joint attention gestures emerging last. This in-depth study of young children's gestures provided a valuable developmental sequence and hierarchy for gestures, in accord with Bruner's categories of communicative functions.

One difference between this study by Crais et al. and the present study is that this factor analysis showed evidence of a fourth category of gestures: gestures that may be learned through imitation and direct instruction from the child's parents. Termed recognitory gestures by Bates, Thal, Fenson, Whitesell, and Oakes (1989), children learn gestures such as "holds fingers up for age" through imitation, and use these gestures to establish reference to external objects, and refer to specific individuals, classes of object, or events. The first factor showed high loadings for three recognitory gestures ("holds up fingers for age", "waves for Hi", and "holds up hands for 'stop'"). The fourth factor showed high loadings on one of the same recognitory gestures as in factor one ("waves for Hi"), plus a second gesture ("claps for 'Yay'").

Rasch analysis for the whole sample showed the developmental order of gesture acquisition for these participants: the most difficult to endorse gestures were "fingers to lips for shh-quiet", followed by "pulls adult's hand to indicate something child wants"; the easiest gestures for parents to endorse were "points to draw attention", "claps for Yay", and "points to self for 'me' or 'my turn'".

This order of some of the easiest gestures was confirmed in Olson and Mazur's (2011) study of infants, ages one year, one month old, which showed that the most frequent gesture was extending an object to show their parents, followed by pointing, or reaching gestures. When the infant is approximately nine months old, communication skills develop further as the child begins to use proto imperative gestures (requests for an object by reaching or pointing to it), and protodeclarative gestures (child points to something of interest in order to share attention with an adult) (Lock & Zukow-Goldring, 2010).

One explanation for the developmental sequence of gestures in this study is that some of the gestures in the *Checklist of Children's Gestures* were ephemeral: children may have used these gestures when younger, but no longer used them as their expressive language skills developed. In a pilot study of an earlier iteration of the *Checklist of Children's Gestures,* parents noted in the margin of the test form that their child had used the gesture when younger, but the gesture dropped out when the child acquired the word that expressed the same meaning. However, a longitudinal study of young children who are in the prelinguistic stage, followed until the two word stage of language development, is needed to determine the nature of gesture use over time.

This ephemeral nature of children's gestures was confirmed by Rowe and Goldin-Meadow's (2008) study. During the second year of a child's life, gesture plus word combinations

precede two-word phrase productions, and the gesture modality becomes elaborated before the verbal modality. This continues into the middle of the child's second year, when a rapid increase in words occurs, since the child now has the referential insight that words are labels for objects and actions. The child combines two words by the end of second year, and, at the same time, the child uses gestures less frequently. Gestures, however, do not disappear entirely, but instead take on a new role to express information that is not stated in the child's words.

At 12 months of age, the infant moves further into the language domain in both the gesture and language modalities. First, the child begins to specify the objects he or she sees by using deictic (pointing) and iconic (hands and the speech express the same concept at the same time) gestures, and which actions the child wants to occur.

Gestures predominate until about 16 months of age, when words become more prevalent (Iverson & Goldin-Meadow, 2005). When the infant is between 17 and 18 months of age, the child's gestures begin to co-occur with words. These gestures typically reinforce, or express the same content as the word (Goldin-Meadow, 2003). In another longitudinal study, Iverson and Goldin-Meadow (2005) examined children's complementary gestures (gestures expressing the same concept as the spoken word) and supplementary gestures (gestures that provide different, but related, information from the word). In the first of eight sessions, nine out of the 10 children produced the majority of references to objects in gesture only, and not speech. However, by the eighth session, all object labels were produced in speech, and no references were produced in gesture.

A third explanation for the developmental sequence or difficulty level of some gestures is that many of the gestures on the *Checklist of Children's Gestures* require a child to have adequate fine motor skills ("holds up fingers for age"; "places fingers to lips for quiet") or gross

motor skills ("Shakes head for 'yes' or 'no'"), and it is possible that some participants had difficulty in motor areas. Also, some of the gestures require the child to have acquired semantic complexity ("places fingers to lips for "shh-quiet").

This study also indicates that the parent report is a reliable and valid method to test gestures, as evidenced by parents from a wide variety of educational levels and SES groups who participated in this study. Crais et al. (2004) found: 91% congruence between parent report of consistent or new behaviors/gestures, and the number of gestures observed by the researchers, confirming the validity of a parent report test of gestures. The *Checklist of Children's Gestures* uses recognition, not recall format, which researchers believe is more reliable than retrospective reporting (Bates et al., 1989).

The reliability of the *Checklist of Children's Gestures* was assessed through Rasch analysis. The real item separation reliability, similar to Coefficient alpha (Smith, 1999), was .94, which indicated that the items created a well-defined variable.

Factor analysis showed high loadings on all 16 gestures that had variance greater than zero, an indication that the *Checklist of Children's Gestures* has construct validity, since the underlying construct was gestures. Since parents responded to all items on the *Checklist of Children's Gestures*, this is an indication of face validity.

The Developmental Pattern of Gesture Use in Children Who are at Risk for Autism

Overall, there was not a significant difference between participants who passed the *M-CHAT* and those who failed. However, there appeared to be a difference in the pattern of gesture use in frequency of different gestures: Participants who failed the *M-CHAT* had lower frequency of some gestures than those who passed on the following: "points to self for me/my turn" , "nods head for "yes", and "places fingers to lips for "shh-quiet". One possible reason for these results is

that the number of participants who failed the *M-CHAT* was too small (n=14) to detect differences. Another possibility is that the *M-CHAT* is a too sensitive test, and some of those who failed the *M-CHAT* may not have had autistic-like symptoms.

Previous studies have indicated the need to examine children's gestures, particularly to determine which ones that are lacking, for diagnostic purposes. Specifically, the absence of giving, pointing, and waving may be a predictor of autism and is a diagnostic criterion in the DSM-4 (Filipek et al., 2000). One study by Goodhart and Baron-Cohen (1993) studied the protoimperative pointing gesture, and only 25% of the children with ASD used the protodeclarative pointing gestures, compared to 90% of the children who were typically developing. Therefore, the pointing gesture may have diagnostic value, and the absence of protodeclarative pointing could be a diagnostic sign of language or developmental delay. It was suggested that the types of pointing gestures that a child uses be assessed in a clinical evaluation.

Gestures and demographic measures. Stepwise regression was conducted to determine the relationship among gesture use and the demographic measures of gender, language environment, age, ethnicity, parental education level, and SES. Results indicated that there was a significant difference between group means for ages two and three year olds, and low vs. high SES on the dependent variable of Gesture Ability Measure on the *Checklist of Children's Gestures of Children's Gestures.* Parental education level, gender, language environment, ethnicity, and low vs. medium SES were not significant. Comparison with other studies is difficult since some studies of gesture and language have not included participants who were from lower SES groups (Bates, Thal, Fenson, Whitesell, & Oakes, 1989).

The lack of significant differences related to educational level or SES are in contrast to a study by Rowe, Raudenbush, and Goldin-Meadow (2012), who found that family income,

mothers' education level, and child gesture were significantly related to parent education. Children from families with higher income and education levels had greater cumulative vocabulary skills at age two years, five months, and had faster rate of increase in vocabulary skills than children from families with lower SES. Child gesture showed a significant effect on vocabulary, controlling for SES and parent input.

The present study showed that the language environment of the child was not a significant factor in either the stepwise regression (dependent variable was gestures) or the hierarchical regression (dependent variable was sum of language scores on the *Bayley*). Comparison to other research is difficult, since many studies of gesture and language exclude bilingual participants. One explanation for these results may be that many early gestures in the *Checklist of Children's Gestures* are universal, therefore there was no significant difference between bilingual and English-only speaking participants.

Variance in Language Scores Explained by *M-CHAT* Status and Gestures

The results indicated that gesture scores predicted a significant amount of variance in the sum of language scores on the *Bayley*. Hierarchical regression analysis was conducted, and the first block was demographic variables (gender, language environment, age, ethnicity, parental education level, and SES), the second block consisted of *M-CHAT* status, and the third block was the Gesture Ability Measure from the *Checklist of Children's Gestures*. The Gesture Ability Measure added an additional 2.3% of the variance ($p<.05$), demographic variables explained 38.9% of the variance, ($p<.01$) in the sum of language scaled scores on the *Bayley Scales of Infant and Toddler Development*; *M-CHAT* status accounted for an additional but non-significant 1.6% of the variance in language scores.

Similar results were found in Qiu, Lopez, and Lord's (2007) longitudinal study of gestures and language skills. Gestures at age two predicted expressive language skills at age nine for a group of children with autism. Another gesture measure was used, the *MBCDI* Words and Gestures, and was administered at two years of age, at three years of age, and finally at age nine. One predictor variable was early and late appearing gestures, as measured on the Words and Gestures subtest of the *MBCDI.* Regression analysis showed that, for the children with autism, the number of later occurring gestures at age two predicted expressive language skills at age nine for children with autism.

Rowe, Ozcaliskan, and Goldin-Meadow (2008) also found a relationship between gestures and language scores, with 27% of the variance in the *Peabody Picture Vocabulary Test* (PPVT) scores explained by children's gesture types. They examined the type and frequency of children's gesture use at 14 months and compared it to vocabulary skills at 42 months on the *Peabody Picture Vocabulary Test* (PPVT)*,* a measure of receptive vocabulary skills (Dunn & Dunn, 1981). Results indicated that PPVT scores were correlated with the children's word types at 14 months, and when word types were controlled, the child's type and frequency of gestures at 14 months were related to the PPVT scores at 42 months. At 14 months, regression analysis showed that the number of different words the children produced explained only 12% of the variance in PPVT scores at 42 months. However, 27% of the variance in PPVT scores was explained by the children's gesture types.

Rowe, Raudenbush, and Goldin-Meadow (2012) found a strong relationship between early gesture use (at 14 months) and later vocabulary skills. Children's gestures at 14-30 months were strong predictors of vocabulary skills at two years, five months, suggesting that gestures were an indication of children's underlying language skills. Interestingly, the authors' suggest

that the child's gestures may have led to increased vocabulary skills by eliciting more verbal feedback from the parents. Although a causal effect cannot be inferred, but since parent input was significantly related to child gesture, and child gesture was related to vocabulary skills, the authors concluded that the children may have been socialized to gesture more (or less) during interactions with their parents.

The present study found a relationship between gestures and the sum of language scaled scores on the *Bayley,* which is a composite of receptive and expressive language skills. One study found a strong correlation (.65) between gestures and language comprehension. Thal, O'Hanlon, Clemmons & Fralin (1999) examined the concurrent validity of a parent report measure of gestures in toddlers, the *MCDI: Words* and *Gestures*, and the relationship to language *on the Preschool Language Scale-revised* (PLS-R). Results suggest that the number of gestures that a child produces may be a predictor of language comprehension for toddlers with language delay.

Limitations and Suggestions for Further Research

A number of limitations in the present study suggest caution in the interpretation of findings. First, selection bias may have been one threat to internal validity, since participants self-selected to be part of the Growing Baby study and were not randomly selected from the population. The participants were also from one geographic location, Chicago. Two other demographic variables that were not representative of the general population were SES and the education level of the primary caregiver. The sample included 60% who attended four years of college or held a graduate degree. Also, 56.4% of the sample had household incomes of 50K and over, compared to 25.1% with incomes under 50K, and 13.4 % on public assistance. These high income and educational levels may limit generalizing these results to the whole population.

Selection bias may also have affected the results of the stepwise regression analysis since results indicated, other than age, that the only demographic variable that explained Gesture Ability Measure scores at a significant level ($p<.01$) was SES (low vs. high SES), which explained another 2.3% of the variance ($p<.05$). Although the demographic variables of age and SES (low vs. high) accounted for 20% of the variance ($p<.05$) in Gesture Ability Measure on the *Checklist of Children's Gestures*, none of the other demographic variables (education, gender) significantly explained any variance. Future research with more heterogeneous education levels and SES distributions may result in demographic variables explaining more of the variance in gesture scores.

Another limitation in the present study is that, although 44 (24.6%) of the participants were reportedly bilingual (compared to 68.2% English speaking participants), the relative exposure to two languages is unknown. Spanish was the predominant language that the majority of parents reported, but several other languages were also reported: French, Polish, and Russian. Also, some parents reported that their child was bilingual, and noted that personnel at their child's daycare center spoke a second language. However, it was not known if a second language was also spoken in the child's home. Future studies of gestures and language should include detailed questions about the children's first and second languages, or whether they were learning two languages simultaneously.

Possible threats to external validity are that six of the participants were reportedly receiving speech-language therapy at the same time that they participated in the Growing Baby study. This was not one of the questions asked in this study, or in the "Growing Baby" study; therefore, additional participants may have been receiving speech-language therapy. The incidence of preschool aged children receiving speech-language therapy services ranges from

two to 19% of the population (asha.org); therefore, in the present study, six children out of 179 (3.35%) falls within this range, indicating that this was a representative sample.

Although it is not known what type of speech-language therapy services the six participants received (oral motor, feeding, articulation, fluency, or language therapy), these participants' sum of language scaled scores on the *Bayley* ranged from 12-27, with a mean scaled score of 18.8, an indication that these six participants may not have been receiving language therapy. Another threat to validity is that the participants may have learned gestures and similar signs in the course of speech-language therapy (e.g., one American Sign Language sign that is similar to an item on the *Checklist of Children's Gestures of Children's Gestures* is pointing to oneself to indicate "me"). In addition, qualitative analysis of parents' responses to the two open-ended questions in the *Checklist of Children's Gestures* ("What other gestures does your child makes?" and "When your child uses these gestures?") showed that 15 parents reported that their child had been taught a few signs. The most common were the American Sign Language signs for "please" and "more". It is possible that these conditions affected the results of the study. Future studies should ask parents whether their children are receiving speech-language services and/or learned sign language.

There were several indications that the age levels of the participants was the primary limitation in this study. It is likely that children ages two and three were too old for studying many of the gestures. Two gestures had zero variance ("hold objects up" and "pushes food away"), indicating that 100% of the participants used these gestures; several other gesture items had high frequency of responses; only two out of the 179 participants did not use the gesture of "raises arms up", and only three participants did not "shake their head for "no"", "point to request objects", or "claps hands for "Yay"".

Similarly, Rasch analysis showed a lack of gestures at the difficulty level of many of the participants: many participants had an ability level at measure 4 (high ability), but there were no gesture items at that difficulty level. Several participants' ability level was at measure 3, but there were no gestures at their ability level. It is possible that the gestures in the *Checklist of Children's Gestures* did not target gestures difficult enough for the two age groups in the sample. Future studies with younger participants may show a difference in the difficulty level of gestures.

Another indication that the older age levels of participants was a limitation was the results of stepwise regression: age alone explained 18.5% of variance in Gesture Ability Measure scores at a significant level ($p<.01$); SES (category of low vs. high) explained another 2.3% of the variance ($p<.05$), but no other demographic variables were significant. The explanation of the ephemeral nature of gestures may explain the results of age: children may use some of these gestures when younger, but no longer use them as their expressive language skills develop.

Although the sample size of 179 was sufficient to conduct Rasch and regression analysis, Rasch analysis could not be performed on the 14 participants who failed the *M-CHAT* due to the small sample size. Instead, descriptive statistics were performed between the group who passed the *M-CHAT, v*s. the participants who failed the *M-CHAT* used. Limited sample size also affected the chi-square analysis between the two age groups on the frequency of the 16 gestures that had variance over zero. Although the assumption of independence of samples was met, the assumption of expected frequencies over five in each cell was not met for seven of the gestures. Larger sample size would permit chi-square testing and Rasch testing for sub-groups, such as those that failed the *M-CHAT*.

The psychometric properties of the reliability and validity of the *Checklist of Children's Gestures* were adequate, but another limitation was the aforementioned lack of difficulty level of

gesture items. The Rasch variable map indicated that more difficult gesture items are needed on the *Checklist of Children's Gesture* in future research.

Another limitation of measures in the study was the *M-CHAT*. It is validated for screening toddlers from 16 to 30 months of age to assess for risk of autism spectrum disorders, but 82 of the participants in the gesture study were three years old, six months older than the upper age limit of the *M-CHAT*. Second, the *MCHAT* has a high false positive rate, with sensitivity at 87% and specificity at 99%. The authors wanted to maximize sensitivity of the test, (the number of children with a disorder who are identified by screening); therefore, not every child who scores in the at-risk category will be diagnosed with autism (Robins, Fein, & Barton, 1999). This may have affected the results of the hierarchical regression, since *M-CHAT* status accounted for only 1.6% of the variance in the sum of language scores on the *Bayley Scales of Infant and Toddler Development*, which was not at a significant level. An age appropriate screening test of autism may have resulted in different outcomes.

The primary suggestion for future research on the relationship between children's gestures and oral language is longitudinal design, possibly starting with infants as young as six months. This could enable researchers to determine when particular gestures develop, when gestures drop out as a child begins to express words, and how gesture use changes over time. Observational studies of children's gestures, combined with parent report in the *Checklist of Children's Gestures*, are needed for validity.

Implications for Practice

Since this study found that gestures predict language scores on the *Bayley,* language clinicians can use this information to help allay parents' fears that their child's use of gestures will delay or constrain their expressive language skills. However, the sum of language scaled

scores on the *Bayley* was used, which includes both the receptive and expressive language composite. Future studies should analyze the effect of gestures on receptive and expressive language skills separately.

These results indicate that the use of gestures is related to children's overall language skills, and therefore should be assessed during language evaluations. This study's information on the developmental sequence of gestures and gesture categories can help clinicians in assessment as well as intervention planning. Clinicians should look at the developmental order of gestures from the Rasch analysis with caution, since only two and three year old children were in this sample, and no younger participants.

Although it appears that the factor analysis did not group the gestures on the *Checklist of Children's Gestures* into Bruner's (1983) three categories of communicative function: (to regulate behavior, to establish joint attention, and to initiate social interaction), other studies (Crais, Douglas, & Campbell, 2004) showed that behavior regulation gestures were the first gestures to emerge, followed by social interaction gestures. Therefore, the factor analysis may also reflect the two ages in the sample (two and three year olds).

Although this study did not bear this result out, due to a small sample size of participates who failed the *M-CHAT,* the absence of giving, pointing, and waving may be a predictor of autism and is a diagnostic criterion in the DSM-4 (Filipek et al., 2000). Studies of pointing gestures (Goodhart & Baron-Cohen, 1993) showed only 25% of the children with ASD used the protodeclarative pointing gesture, compared to 90% of the children who were typically developing. These results indicate that pointing may have diagnostic value, and the absence of protodeclarative pointing could be a diagnostic sign of language or developmental delay.

This study also indicates that the parent report appears to be a feasible way to test gestures, as evidenced by the fact that parents from a wide variety of educational levels and SES had no difficulty completing the checklist. Researchers recommend that speech-language pathologists (SLPs) create a comprehensive profile of children's gestures during a speech-language evaluation (Crais, Watson, & Baranek, 2009). The *Checklist of Children's Gestures* takes five minutes for parents to complete, thereby being a time-saving method to assess children's gestures, as opposed to clinical observation or asking parents to recall which gestures their child uses, which has been viewed as an unreliable method. Additionally, the *Checklist of Children's Gestures* has validity and reliability (.94), and uses the parent report format. Overall, the *Checklist of Children's Gestures* shows promise as a reliable and valid method of assessing young children's gestures.

The results of the study may also have implications for clinical practice. Early childhood teachers and early intervention providers may use the *Checklist of Children's Gestures* to determine if a young child, nonverbal child has nonverbal communication skills. Since gestures are related to language skills, it may also be beneficial to target gestures in language intervention programs. Teachers, parents, and therapists may consider modeling gestures to aid young children's language skills.

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Appendix A

Checklist of Children's Gestures

Child's Name: _____ Age: year(s): ____ months: ____

Child's date of birth: _____ Gender: male □ female □

Languages spoken to the child: English only □ Other □ Please list: _____

Ethnic Background: African American □ Hispanic □ White □ Asian □ Other □

Directions: Dear Parents: Many young children use gestures to communicate their ideas and needs. We would like to find out what gestures your child uses or imitates.

Please check the box under **"Yes"** if your child makes the gesture and "**Not yet**" if he or she does not use this gesture right now, or "**imitates"** if your child copies the gesture when someone else does it first. There are no right or wrong answers.

Gesture	Yes	Not Yet	Imitates
1. My child waves hand for "Hi" or "Goodbye".	☐	☐	☐
2. My child shakes his/her head for "no".	☐	☐	☐
3. My child points to something to ask for it.	☐	☐	☐
4. My child shrugs shoulders or holds hands or arms up to say "where is it?"	☐	☐	☐
5. My child nods his/her head to answer "yes".	☐	☐	☐
6. My child puts a finger to his or her lips for "shh" or "quiet".	☐	☐	☐
7. My child holds up fingers for his or her age.	☐	☐	☐
8. My child holds his or her arms up to ask to be picked up.	☐	☐	☐

Appendix A (continued)

GESTURE	Yes	Not Yet	Imitates
9. My child points to himself or herself to indicate "mine", "me" or "my turn".	☐	☐	☐
10. My child holds up objects to show me.	☐	☐	☐
11. My child points to something to call my attention to it.	☐	☐	☐
12. My child pushes food away when he/she does not want it.	☐	☐	☐
13. My child gives "high five" or fist bump.	☐	☐	☐
14. My child moves his/her hands up and down when excited.	☐	☐	☐
15. My child pulls an adult's hand to indicate something that he wants.	☐	☐	☐
16. My child holds hand up for "stop".	☐	☐	☐
17. My child stomps his/her feet when mad.	☐	☐	☐
18. My child claps his/her hands together to indicate "Yay!"	☐	☐	☐

19. Did we leave out any gestures that your child makes? What are they? How does your child make this gesture?

_____

_____

_____

20. If you answered number 19, please tell us *when* your child uses these gestures? Please describe what these gestures mean to your child, and what they communicate.

_____

_____

_____

Appendix B

M-CHAT

Please fill out the following about your child's usual behavior, and try to answer every question. If the behavior is rare (you've only seen it once or twice), please answer as if your child does *not* do it.

1.	Does your child enjoy being swung, bounced on your knee, etc.?	Yes No
2.	Does your child take an interest in other children?	Yes No
3.	Does your child like climbing on things, such as up stairs?	Yes No
4.	Does your child enjoy playing peek-a-boo/hide-and-seek?	Yes No
5.	Does your child ever pretend, for example, to talk on the phone or take care of a doll or pretend other things?	Yes No
6.	Does your child ever use his/her index finger to point, to ask for something?	Yes No
7.	Does your child ever use his/her index finger to point, to indicate interest in something?	Yes No
8.	Can your child play properly with small toys (e.g. cars or blocks) without just mouthing, fiddling, or dropping them?	Yes No
9.	Does your child ever bring objects over to you (parent) to show you something?	Yes No
10.	Does your child look you in the eye for more than a second or two?	Yes No
11.	Does your child ever seem oversensitive to noise? (e.g., plugging ears)	Yes No
12.	Does your child smile in response to your face or your smile?	Yes No
13.	Does your child imitate you? (e.g., you make a face-will your child imitate it?)	Yes No
14.	Does your child respond to his/her name when you call?	Yes No
15.	If you point at a toy across the room, does your child look at it?	Yes No
16.	Does your child walk?	Yes No
17.	Does your child look at things you are looking at?	Yes No
18.	Does your child make unusual finger movements near his/her face?	Yes No
19.	Does your child try to attract your attention to his/her own activity?	Yes No
20.	Have you ever wondered if your child is deaf?	Yes No
21.	Does your child understand what people say?	Yes No
22.	Does your child sometimes stare at nothing or wander with no purpose?	Yes No
23.	Does your child look at your face to check your reaction when faced with something unfamiliar?	Yes No

Appendix C

Demographic questions answered by families in the Growing baby study at the initial visit included:

Child's gender

Child's date of birth

Highest education of child's primary caregiver

Professional: graduate degree

College graduate

One-three years of college including business school

High school graduate

10-11 years high school

7-9 years of school

Less than 7 years of school

Ethnicity of the child

American Indian or Alaskan Native

Asian

Native Hawaiian or Pacific Islander

African American

White

Hispanic or Latino

Appendix C (continued)

Family's annual income level

Over 100k

50k-100k

25k-50k

Under 25k

Receiving public assistance

Appendix D

UNIVERSITY OF ILLINOIS
AT CHICAGO

Office for the Protection of Research Subjects (OPRS)
Office of the Vice Chancellor for Research (MC 672)
203 Administrative Office Building
1737 West Polk Street
Chicago, Illinois 60612-7227

Approval Notice
Initial Review – Expedited Review

July 17, 2012

Eileen Brann, MS
Special Education
RE: **Protocol # 2012-0530**
"Relationship Between Young Children's Gestures and Language Development"

Dear Ms. Brann:

Members of Institutional Review Board (IRB) #2 reviewed and approved your research protocol under expedited review procedures [45 CFR 46.110(b)(1)] on July 13, 2012. You may now begin your research.

Your research meets the requirements for review under expedited review procedures [45 CFR 46.110] Category: 5

(5) Research involving materials (data, documents, records, or specimens) that have been collected, or will be collected solely for non-research purposes (such as medical treatment or diagnosis).

Please note the following information about your approved research protocol:

Please note that the DVDs used in this research must either be destroyed or a data transfer agreement must be obtained when Protocol 2008-0479, the study upon which this protocol is dependent, is closed.

Protocol Approval Period: July 13, 2012 – July 12, 2013
Approved Subject Enrollment #: 220
Additional Determinations for Research Involving Minors: The Board determined that this research satisfies 45CFR46.404, research not involving greater than minimal risk. Therefore, in accordance with 45CFR46.408, the IRB determined that only one parent's/legal guardian's permission/signature is needed.
Performance Site: UIC

Appendix D (continued)

Sponsor: None

Research Protocol:

a) Relationship between Young Children's Gestures and Language Development (no footer)

Recruitment Material:

a) No recruitment materials will be used - data was previously collected by researchers at the Brain-Body Center under Protocol 2008-0479

Informed Consent:

a) A waiver of parental permission has been granted under 45 CFR 46.116(d) for secondary analysis of data collected under Protocol 2008-0479 (written parental permission obtained under Protocol 2008-0479)

Assent:

a) A waiver of child assent has been granted under 45 CFR 46.116(d) for infants whose parents have granted permission for their participation in Protocol 2008-0479

Please note the Review History of this submission:

Receipt Date	Submission Type	Review Process	Review Date	Review Action
06/15/2012	Initial Review	Expedited	06/26/2012	Returned To PI
07/11/2012	Response From PI	Expedited	07/13/2012	Approved

Please remember to:

→ Use your **research protocol number** (2012-0530) on any documents or correspondence with the IRB concerning your research protocol.
→ Review and comply with all requirements of the,
"**UIC Investigator Responsibilities, Protection of Human Research Subjects**"

Please note that the UIC IRB has the right to ask further questions, seek additional information, or monitor the conduct of your research and the consent process.

Please be aware that if the scope of work in the grant/project changes, the protocol must be amended and approved by the UIC IRB before the initiation of the change.

We wish you the best as you conduct your research. If you have any questions or need further help, please contact the OPRS office at (312) 996-1711 or me at (312) 996-2014. Please send any correspondence about this protocol to OPRS at 203 AOB, M/C 672.

Sincerely,

Sandra Costello
Assistant Director, IRB # 2
Office for the Protection of Research

Appendix D (continued)

Subjects

Enclosures:

1. **UIC Investigator Responsibilities, Protection of Human Research Subjects**
2. **Data Security Enclosure**

cc: Mavis Donahue (faculty advisor), Special Education, M/C 147
Elizabeth Talbott, Special Education, M/C 147

VITA

Eileen M. Brann, M.S., M.Ed., Ph.D.

Education

Ph.D., Special Education — 2005-2013
University of Illinois at Chicago, Chicago, Illinois
Advisor: Mavis L. Donahue, Ed.D.

M.Ed., Measurement, Evaluation, Statistics, and Assessment — 2008-2011
University of Illinois at Chicago, Chicago, Illinois
Advisor: Everett Smith, Ph.D.

M. S., Speech Pathology
Illinois State University, Normal, Illinois — 1975-1976

B. S., Speech Pathology
Illinois State University, Normal, Illinois — 1971-1975

Employment

Adjunct instructor, Department of Communication Sciences and Disorders
Saint Xavier University — Fall, 2012 to present

Speech-Language Pathologist — 1991-present
Private Practice
Oak Park, IL.
Provide evaluations and therapy for children and adults with speech, language, or stuttering disorders; school consultant: provide speech-language evaluations in Spanish

Rehabilitation Institute of Chicago, Chicago, IL. — Fall, 2010
Clinician, Intensive Aphasia Program
Program Director, Dr. Leora Cherney

MacNeal Hospital, Berwyn, IL. — 1989-1991
Co-coordinator, Speech Pathology Department
Member of Physical Medicine and Rehabilitation team; Educated medical and nursing staff on diagnostics and treatment of dysphagia in neurologically impaired patients supervised Speech Pathology staff; developed audiology department

VITA (continued)

Loyola University Medical Center, Maywood, IL. 1989-1991
Senior Speech Pathologist
In charge of quality assurance program for department; Supervised clinicians; educated medical and healthcare students about dysphagia, aphasia, and cognitive impairment; provided dysphagia evaluations and speech-language therapy to adults with neurological disorders

Gottlieb Memorial Hospital, Melrose Park, IL. 1984-1989
Developed inpatient and pediatric outpatient Speech Pathology department; developed videofluoroscopy program for dysphagia

Oak Park Speech and Hearing Center, Oak Park, Il. 1981-1984
Provided speech-language pathology services in skilled care facilities, hospitals, and pediatric outpatient centers; supervised clinician

District 123, Oak Lawn, IL. 1980-1981
Evaluation and treatment of school aged children with communication disorders

Carl Sandburg High School, Orland Park, IL. 1976-1980
Evaluation and treatment for high school students with communication disorders, including students with learning disabilities and cognitive impairments

Presentations

Brann, E. M. (November, 2011). *The gesture and language relationship in children with autism and language impairments*. Invited talk at the Brain-Body Center of the University of Illinois at Chicago Medical Center.

Brann, E. M. (May, 2011). *Children's gestures and language skills: Examining the relationship.* Poster presented in the Department of Special Education at the University of Illinois, Chicago, IL.

Brann, E. M. (November, 2010). *The speech-language pathologist in the medical setting.* Invited talk at the Department of Communication Sciences and Disorders at Elmhurst College for the National Student Speech Language Hearing Association, Elmhurst, IL.

Brann, E. M. (March, 2010). *Children's gestures and language skills: Results of a pilot study.* Poster presented in the Department of Special Education at the University of Illinois, Chicago, IL.

VITA (continued)

Brann, E. M. (March, 2010). The *speech-language pathologist and current gesture research: Ideas for intervention.* Invited talk at the South Cook County Speech, Language, and Hearing Association, Crestwood, IL.

Brann, E. M. (November, 2009). *The role of gestures in language development*. Paper presented at the annual convention of the American Speech Language Hearing Association, New Orleans, LA.

Brann, E. M. (November, 2008). *The role of gestures in language and learning*. Poster presented at the annual convention of the American Speech Language Hearing Association, Chicago, IL.

Brann, E. M. (February, 2008).*What do gestures have to do with language development?* Talk presented at the Illinois Speech and Hearing Association Annual Convention, Arlington Heights, IL.

Donahue, M. L., Brann, E. M., & Simpson, A. (February, 2007). *Popular beliefs about language development.* Poster presented at the Illinois Speech and Hearing Association Annual Convention, Arlington Heights, IL.

Donahue, M. L., Brann, E. M., & Simpson, A. (November, 2005). *Popular beliefs about language development.* Poster presented at the American Speech Language Hearing Association Annual Convention, San Diego, CA.

Publications

In preparation: Brann, E. (2011). *The Role of Gestures in Language Development:Results of a pilot study.*

Research Experience

Research assistant, "The Growing Baby Study: Changes in autonomic and behavioral regulation in infants between ages 6-36 months". Principal investigator, Dr. Stephen Porges, Department of Psychiatry, University of Illinois at Chicago, Chicago, IL. — Fall, 2011 to Summer, 2012

Key research personnel, "The Growing Baby Study: Changes in autonomic and behavioral regulation in infants between ages 6-36 months". Principal investigator, Dr. Stephen Porges, Department of Psychiatry, University of Illinois at Chicago, Chicago, IL. — Fall, 2010

Pilot research study, *The role of gestures in language development.* University of Illinois at Chicago, Chicago, IL. — Fall, 2009

VITA (continued)

Consultant, research study of adults with Parkinson's Disease. Principal investigator, Dr. Susan Duncan, Department of Psychology, University of Chicago, Chicago, IL. — July, 2008

Teaching Experience

Adjunct instructor, *Development of Language in the Young Child* — Fall, 2012

Language Disorders in Children — Spring, 2013

Saint Xavier University
Department of Communication Sciences and Disorders
Chicago, IL.

Co-instructor*, Language Development, Diversity, and Disabilities* — Spring, 2008
Department of Special Education, University of Illinois at Chicago.
Primary instructor, Dr. Mavis Donahue

Guest lecturer, *Language Development, Diversity, and Disabilities* — June*,* 2005
Department of Special Education, University of Illinois at Chicago

Instructor, S*peech Reading for the Hard of Hearing* — Spring, 1984
Triton Community College, River Grove, IL. — Fall, 1985

Teaching Interests

Language Development
Language Disorders
Evidence Based Practice in Communication Sciences and Disorders
Fluency Disorders
Assessment and Intervention of Language Disorders in Bilingual Children
Research Procedures and Methods in Communication Sciences and Disorders

Mentoring Experience

Supervision of graduate students' clinician practicum in Communication Sciences and Disorders — Spring, 2010

Rush University — Summer, 2003; Fall, 2001

Mentored ten undergraduate students in speech pathology and special education programs as part of private practice — 1995-present

Supervised three speech-language pathologists for Clinical Fellowship Year — 1978; 1983; 1989

VITA (continued)

Professional Credentials
Licensed Speech-Language Pathologist, State of Illinois

Certificate of Clinical Competence, American Speech Language Hearing Association

Committee and Service Work

Reviewer for National Professional Development Center on Autism Spectrum Disorders, Evidence-based practice update workgroup	2012
Committee member, Legislative and Regulatory Affairs Illinois Speech-Language Hearing Association	1996-1997
Board member, Membership Chair Chicago Audiology-Speech-Language Association	1996-1999
Tutor, Literacy Volunteers of America	1984-1994

Awards

Children of Veterans Scholarship	2006-2010
Award for Continuing Education, American Speech Language Hearing Association	1994

Memberships
American Speech Language Hearing Association (special interest divisions: fluency and fluency disorders; neurophysiology and neurogenic speech-language disorders)

American Academy of Private Practice in Speech Pathology and Audiology

Chicagoland Evaluation Association

Illinois Speech and Hearing Association

International Society for Gesture Studies

Society for the Neurobiology of Language

Society for Social Neuroscience

VITA (continued)

Languages
Spanish

American sign language

References
Available upon request