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# Patterns of early lexical and gestural development in children with Williams syndrome.

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# PATTERNS OF EARLY LEXICAL AND GESTURAL DEVELOPMENT IN CHILDREN WITH WILLIAMS SYNDROME

By

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A Dissertation Approved on

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# DEDICATION

Para Rodrigo, Mateo, Valentina, y Felipe, por ser mi mayor motivación.

Para mi mamá, gracias a ti esto es una realidad.

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- Valen: “Open different doors. You may find another you there that you never knew was yours. Anything can happen” (Mary Poppins).
- Felipe: desde ya me dices cuando leemos: “You have brains in your head,

you have feet in your shoes. You can steer yourself any direction you choose" (Dr. Seuss).

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ABSTRACT

PATTERNS OF EARLY LEXICAL AND GESTURAL DEVELOPMENT IN CHILDREN WITH WILLIAMS SYNDROME

Angela M. Becerra

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The purpose of this dissertation was to investigate the early gestural and lexical development of very young children with Williams syndrome (WS), including the predictive value of variability in lexical and gestural abilities at age 24 months for variability in later intellectual and language abilities at 4 years of age. Vocabulary and gestural abilities were measured by the MacArthur-Bates Communicative Development Inventories (CDI, Fenson et al., 2007). Three different sets of analyses were performed.

The first set of analyses addressed the receptive vocabulary (RV), expressive vocabulary (EV), early gesture (EG), late gesture (LG), and total gesture (TG) abilities of a group of 49 18-month-old children with WS. Considerable variability was found for each of these measures. In comparison to the CDI norms for same-aged children in the general population, significant delay was found for each of these abilities.

A second set of analyses further addressed the lexical and gestural abilities of young children with WS. In the first analysis, the EV abilities of 56 24-month-olds and 55 30-month-olds were compared to the CDI norms. Considerable variability was found with almost all children evidencing significant delay. In a second analysis strong concurrent correlations were found among RV, EV, EG, LG, and TG for 18-, 24-, and 30-month-olds. These results supported previous findings of significant relations between lexical and gestural abilities in early development for both young typically developing children and young children with developmental delay.

The final set of analyses focused on longitudinal relations between lexical and gestural abilities in children with WS. In the first analysis, strong and significant correlations between RV, EV, EG, LG, and TG at age 18 months of age and these same abilities at age 30 months were found in a sample of 29 children. In the second analysis, strong relations between age of acquisition of each of three deictic gestures (give, show, and point) and EV at 48 months were found for 39 children with WS. Nevertheless, unlike typically developing children, almost all of the children with WS began to talk before they begin either to point at or to show objects. The final analysis focused on the predictive value of deictic gestures at 24 months, EV at 24 months, and maternal level of education for vocabulary and intellectual abilities at 4 years of age, as measured by standardized assessments, in a group of 27 children. Results indicated that maternal level of education, EV, and deictic gestures at 24 months of age were significant predictors of receptive vocabulary and expressive vocabulary at 4 years of age. EV and deictic gestures at 24 months of age were significant predictors of overall intellectual abilities and verbal abilities at age 4 years. EV was a significant predictor of nonverbal reasoning abilities, and deictic gestures were a significant predictor of spatial abilities at 4 years of age.

The findings from this dissertation provide strong evidence of the importance of early intervention for very young children with WS, with a focus both on facilitating the development of receptive and expressive vocabulary and helping the child comprehend and produce deictic gestures.

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# CHAPTER I

## GENERAL INTRODUCTION

Williams syndrome (WS) is a neurodevelopmental disorder caused by a hemizygous microdeletion of 26 – 28 genes on chromosome 7q11.23 (Hillier et al., 2003, Osborne, 2010). WS is associated with specific medical and physical features including characteristic facial features, cardiovascular disease (especially supravalvar aortic stenosis), connective tissue abnormalities, failure to thrive, and infantile hypercalcemia (Morris, 2010). WS also is associated with specific behavioral characteristics including hypersociability (social disinhibition), attention problems, and anxiety (Klein-Tasman & Mervis, 2003; Leyfer et al., 2009). The intellectual abilities of individuals with WS are typically at the mild disability level, with a range from severe intellectual disability to average. Intellectual abilities present a pattern of relative strengths and weaknesses characterized by relative strengths in verbal short term memory and concrete vocabulary and severe weakness in visuospatial construction (Mervis et al., 2000). Within the language domain, concrete vocabulary is an area of relative strength, whereas relational vocabulary presents the greatest weakness (Brock, Jarrold, Farran, Laws, & Riby, 2007; Mervis & Becerra, 2007; Mervis & John, 2010). Despite the fact that language abilities are a relative strength in individuals with WS, early language development is delayed (e.g., Mervis & Bertrand, 1993, 1997; Mervis & Robinson, 2000).

To date, research on the language development of children with WS has focused primarily on school-aged children. The few studies of early lexical development in children with WS provide evidence for significant delay (Mervis & Robinson, 2000; Mervis & John, 2012; Singer-Harris et al., 2003). A very limited number of studies on WS have examined the characteristics of early gestural and lexical development and the relations among them, and most of these studies have included small samples (Singer-Harris et al., 2003). Very few studies have analyzed the relations of early lexical development to later intellectual and language abilities in children with WS (Becerra, Henderson, John, & Mervis, 2010; Mervis & John, 2012), and there has been no research on the relation of early gestural development to later intellectual or language abilities of children with WS.

The purpose of this project is to determine the characteristics of early lexical and gestural development of children with WS and their relations to later intellectual and language development. I will describe early receptive and expressive vocabulary development and the development of gestural abilities and consider the relations between lexical and gestural abilities concurrently. I will examine the predictive validity of individual differences in early vocabulary and gestural abilities for individual differences in later vocabulary and intellectual abilities. In addition, I will analyze the relation between gestures and lexical abilities by considering the relation of deictic gestures to later lexical and intellectual abilities. The results of the present project will provide a more extensive understanding of early lexical and gestural development in children with WS. If, as I expect, the results provide substantive evidence for a strong relation between early gestural and lexical development and later intellectual and vocabulary abilities, these results will be a strong argument in favor of early speech and language intervention for children with WS.

In the remainder of the introduction, I will review the literature related to early lexical and gestural development in typically developing (TD) children, children with developmental delay (DD), and children with WS. I will also review the literature on the relations among components of early language (receptive and expressive vocabulary) and gestural abilities in TD children, children with developmental delay, and children with WS. Finally, I will review the literature on the predictive validity of early lexical and gestural abilities for later intellectual and language abilities in the same three groups of children.

## Early Lexical and Gestural Development

A wide variety of research assessment tools has been used throughout the years to assess early language development. One widely used, reliable, and cost-effective method to study language is parental report. Currently, the most commonly used language assessment instrument for very young children is the MacArthur-Bates Communicative Development Inventories (CDI; Fenson et al., 1993, 2007).

Research on early communication skills based on the parental report measure that evolved into the CDI began four decades ago. At that time, Bates, Camaioni, and Volterra (1975), in their description of the measure they were developing, reported that it was a cost-effective and reliable tool to assess children’s language, especially for children under 2 years of age. Over the years, the measure evolved from a free-form interview (Bates et al., 1975) to a structured checklist administered orally (Snyder, Bates, & Bretherton, 1981) to the self-administered checklist that is now known as the CDI (Fenson et al., 1993, 2007).

After two decades of being normed, not only for American English but for more than 50 other languages (Dale & Penfold, 2011), the CDI has been widely used as a research instrument to assess early language and gestural abilities of TD children, children with DD, late talkers, and children with various medical conditions (e.g., traumatic brain injury, hearing impairment, premature birth). I will review the findings on early lexical and gestural abilities of TD children and children with DD from studies that used the CDI.

The CDI is divided into two major inventories: Words and Gestures (normed for ages 8 – 18 months) and Words and Sentences (normed for ages 16 – 30 months). The CDI Words and Gestures (CDI-WG) includes a 396-item vocabulary checklist. Parents are asked to report which words their child understands (receptive vocabulary, RV) and which words their child both understands and says (expressive vocabulary, EV). The second part of the CDI-WG includes five subscales: (A) First Communicative Gestures (12 items), (B) Games and Routines (6 items), (C) Actions with Objects (17 items), (D) Imitating Other Adult Actions (15 items), and (E) Pretending to be a Parent (13 items). This second part measures the child's use of communicative and symbolic actions/gestures. The CDI-WS includes a 680-item vocabulary checklist; all of the items included in the CDI-WG vocabulary checklist also are included in the CDI-WS vocabulary checklist. Parents are asked to report which words their child says (EV). A more in-depth description of the CDI is provided in the Method section of Chapter II.

**Early Lexical and Gestural Abilities in TD children**

The study of early language and gestural abilities using the CDI has provided valuable information about developmental trends and variability in TD children. Fenson and colleagues (Fenson, Dale, Reznick, Bates, Thal, & Pethick, 1994) studied the characteristics of early language development in TD children based on the CDI norming sample. This sample included 659 infants and 1,130 toddlers. All children had English as their primary language, although 12% of the sample was exposed to a second language but with less frequency than English. These norms describe the growth of vocabulary, gestural expression, and grammar in children between 8 – 30 months of age. For this research project only vocabulary and gestural abilities will be considered.

Based on the CDI norming sample, a cross-sectional analysis determined that the first signs of RV appear between 8 and 10 months of age. At 9 months of age the median RV size was 29 words ($10^{th}$ percentile had 7 words and $90^{th}$ percentile had 106 words). At 12 months of age the median RV size was 74 words ($10^{th}$ percentile had 21 words and $90^{th}$ percentile had 199 words). For children at 15 months of age the median was 158 words ($10^{th}$ percentile had 57 words and $90^{th}$ percentile had 292 words). At 18 months, the median RV was 260 words ($10^{th}$ percentile had 133 words and $90^{th}$ percentile had 352 words). These findings document great variability in both the onset and development of receptive vocabulary (Fenson et al., 2007).

Data from the CDI-WG evidenced that EV slowly begins to develop for most children at 12 months of age. At 9 months of age the median EV was 0 words ($10^{th}$ percentile had 0 words and $90^{th}$ percentile had 8 words). At 12 months, the median EV was 3 words ($10^{th}$ percentile had 0 words and $90^{th}$ percentile had 29 words). At 15 months, the median was 20 words ($10^{th}$ percentile had 2 words and $90^{th}$ percentile 95 words). At 18 months, the median for EV was 94 words ($10^{th}$ percentile had 18 words and $90^{th}$ percentile had 221 words). Considering data from the CDI-WS, at 18 months median EV size was 86 words ($10^{th}$ percentile had 17 words and $90^{th}$ percentile had 268 words). At 24 months median EV size was 297 words ($10^{th}$ percentile was 77 words and $90^{th}$ percentile was 542 words). At 30 months, median EV size was 548 words ($10^{th}$ percentile had 263 words and $90^{th}$ percentile had 653 words) (Bates et. al., 1995; Fenson et al., 2007). In summary, the cross-sectional data suggest that there is a slow growth in EV through age 15 – 17 months and then a rapid increase. However, there is considerable variability at all ages for TD children. This pattern has been confirmed in longitudinal studies (Bates & Carnevalle, 1993; Robinson & Mervis, 1999).

Fenson et al. (1994) analyzed the age at which parents reported that the children in the norming sample demonstrated the symbolic actions and gestures included in the CDI-WG. As expected from previous research (see Volterra et al., 2005 for a review), the items in subscales A (First Communicative Gestures) and B (Games and Routines) usually appeared earlier than the items on the other subscales. For the majority of children, more than half of the items in subscales A and B had been demonstrated by 12 months of age (mean age of acquisition of 50% of the items for A was 11.3 months and mean age for B was 9.6 months). Mean age of acquisition of 50% of the items of the symbolic gestures and behaviors included in subscale C (Actions with Objects) was 13.7 months, for subscale D (Pretending to be a Parent) was 16.8 months, and for E (Imitating other Adult Actions) was 14.4 months. Based on the age of appearance of the behaviors included in these subscales, Fenson et al. (1994, 2007) categorized early gestures (EG) as those behaviors included in the First Communicative Gestures and Games and Routines subscales. The late gestures (LG) category includes the behaviors in the Actions with Objects, Pretending to be a Parent, and Imitating Other Adult Actions subscales. Thus, EG includes 18 possible gestures and LG includes 45 possible gestures.

The data from the CDI norming sample were used to determine percentile rankings for gestural abilities (Fenson et al., 2007). For EG the median number of gestures at 9 months was 8 (10th percentile had 3 gestures and 90th percentile had 13 gestures). For 12 months of age EG had a median of 11 gestures (10th percentile had 6 gesture and 90th had 15 gestures). At 15 months of age median EG was 14 gestures (10th percentile was 10 gestures and 90th percentile was 17 gestures). At 18 months, median EG was 16 (10th percentile was 13 and 90th percentile was 18 gestures – the maximum possible). In contrast, data from the norming sample for the CDI-WG indicated that the median LG at 9 months was 6 (10th percentile had 2 and 90th percentile had 13 gestures). At 12 months of age the median for LG was 13 (10th percentile was 5 and 90th percentile was 25 gestures). At 15 months of age the median was 24 gestures (10th percentile had 13 and 90th percentile had 35 gestures). At 18 months, the median for LG was 34 gestures (10th percentile had 25 and 90th percentile had 41 gestures).

Further analysis showed that with respect to age of acquisition of deictic gestures, more than 50% of the children at 8 months of age were giving and showing objects, and by 10 months of age more than 50% of the children were pointing to indicate interest in a object at a distance (Fenson et al., 1994). At 11 months 68% of the children produced all three deictic gestures and by 17 months 100% of the children from the CDI norming sample produced all three deictic gestures (Virginia Marchman, personal communication to Carolyn Mervis, January 11, 2016).

**Early Lexical and Gestural Abilities in Children with Developmental Delay**

A limited number of studies has analyzed early lexical abilities in children with developmental delay. These studies have focused primarily on children with Down syndrome (DS) or Autism Spectrum Disorder (ASD); very few studies have focused on children with WS. In this section, where I review the lexical and gestural abilities in children with developmental delay, I will only consider studies which have assessed children's language abilities using the CDI.

*Down syndrome.* Research on children with DS provides evidence for a significant delay in lexical development when compared to TD children. Caselli, Vicari, Longobardi, Lami, Pizzoli, and Stella (1998) studied the early language abilities of 40 Italian children with DS ranging in age from 10 to 49 months (mean 28 months). Using the Italian version of the CDI-WG (PVB; Caselli & Casadio, 1995) they found that mean RV size was 116.4 words (SD = 117.4, range: 0 – 390 words), mean EV size was 26.5 words (SD = 55.5 words, range: 0 – 302 words), and mean total gestures (TG) was 37.4 (SD =18.9, range: 2 – 62 gestures). When compared to the percentile rankings from the norms for the

PVB, these results correspond to the 50th percentile for 14-month-olds for RV, 15-month-olds for EV, and 14-month-olds for TG. These results provide further evidence for a significant delay in early language acquisition in children with DS.

Mervis and Robinson (2000) studied EV in a group of 28 2-year-olds with DS (mean CA: 2.5 years; SD = .33). Mean EV size was 66.35 words (SD = 79.24; range: 0 – 324 words). Thirteen of the children were young enough to compare their EV sizes with the CDI norms. Twelve of these children scored below the 5th percentile for the general population (the lowest percentile included in the norms); the remaining child scored at the 8th percentile. These results also show a delay in lexical development in children with DS. The variability of EV size for children with DS was similar to the variability found in the general population.

In an effort to analyze lexical growth trends and individual differences in a large sample of children with DS, Berglund and colleagues (Berglund, Eriksson, & Johansson, 2001) studied 330 children between the ages of 1.00 and 5.5 years. Lexical abilities were determined using the Swedish version of the CDI-WS (SECDI, Berglund, & Eriksson, 2000). Results showed that 12% of the children had started to talk before age 24 months and 80% had started to talk before age 36 months. Median EV size (50th percentile) was 0 words for 12 – 17-month-olds, 10 words for 24 – 30-month-olds, 16 words for 36 – 41-month-olds, 53 words for 48 – 54-month-olds, and 198 words for 60 – 66-month-olds. Significant individual differences were found. For example, the EV range for 5-year-olds was from 0 words to > 600 words. Results showed that a very small proportion of children with DS started to talk at about the same age as TD children, but EV acquisition was delayed for almost all children relative to the norms from the SECDI.

A more recent longitudinal study of lexical development in children with DS analyzed the developmental trend of vocabulary acquisition in a group of 18 Italian children (Zampini & D'Odorico, 2013). A sample of 10 2-year-old children with DS was followed until they were 3 years of age, and 8 3-year-old children were followed until they were 4 years. Children's EV abilities were assessed using the PVB in 6-month intervals. Results showed that at 24 months mean EV size was 9 words (SD = 4.83, range: 4 – 21), at 30 months mean EV size was 18 words (SD = 11.18, range: 4 – 40), at 36 months mean EV was 47.36 words (SD = 61.83, range: 0 – 243), at 42 months mean EV was 116.61 words (SD = 127.55, range: 0 – 499), and at 48 months mean EV was 205.5 words (SD = 169.78, range: 1 – 581). These results showed significant variability in EV for each of the ages studied.

*Autism Spectrum Disorder.* Early lexical and gestural abilities have also been studied in children with ASD. Charman and colleagues (Charman, Drew, Baird, & Baird, 2003) analyzed the early lexical abilities of a sample of 134 children (116 boys, 18 girls) with a mean CA of 3.16 years (SD = 1.2, range: 1.5 – 7.33 years). Results showed that for the children between ages 1.5 and 1.99 years mean RV was 56.9 words (SD = 76.2), between 2.00 and 2.99 years mean RV was 118.9 words (SD = 111.4), between 3.00 and 3.99 years mean RV was 134.2 words (SD = 100.1), and for children older than 4 years of age mean RV was 199.7 words (SD = 107.7). Mean EV was 6.7 words (SD = 17.0) for children aged 1.5 – 1.99 years, 32.4 words (SD = 80.2) for children aged 2.00 – 2.99

years, 54 words (SD = 67.4) for children aged 3.00 – 3.99 years, and 51 words (SD = 66.1) for children 4 years or older. These results confirm findings from previous studies (e.g., Tager-Flusberg et al., 1990) that showed a significant delay in language development in children with ASD.

Charman and colleagues (2003) also performed a cross-sectional analysis of gestural abilities in children with ASD, as measured by the CDI-WG. Table 1 shows the findings for EG, LG, and TG by chronological age (CA). These results show significant delay and great variability in EG and LG behaviors in children with ASD.

Table 1

*Descriptive Statistics for Gestural Abilities of Children with ASD (Charman et al., 2003)*

| | Gestural Abilities[1] | | |
|---|---|---|---|
| CA (in years) | EG Mean (SD) | LG Mean (SD) | TG Mean (SD) |
| 1.55 – 1.99 (N = 20) | 7.2 (3.6) | 13.6 (8.0) | 20.7 (11.4) |
| 2.00 – 2.99 (N = 47) | 8.7 (4.1) | 21.2 (11.0) | 29.9 (14.7) |
| 3.00 – 3.99 (N = 39) | 8.6 (3.8) | 22.7 (8.9) | 31.0 (12.0) |
| 4.00 or older (N = 28) | 8.9 (4.1) | 25.6 (9.9) | 34.6 (13.1) |

[1]Maximum = 18 for EG, 45 for LG, and 63 for TG

*Williams syndrome.* A variety of studies has determined that onset of language development is delayed for most children with WS. The first study to analyze early lexical abilities was performed by Thal, Bates, and Bellugi (1989). They reported characteristics of early vocabulary for two girls with WS. One girl (child A) was 5 years

6 months and the other girl (child B) was 23 months at the time of the study. Using the Language and Gesture Inventory (a precursor of the CDI; Bates et al., 1985), Thal et al. determined that child A had a RV of 281 words and an EV of 142 words, and that child B had a RV of 314 words and EV of 34 words. Due to the small sample size and age difference between the two girls little can be concluded from these results.

In a later study, Singer Harris, Bellugi, Bates, Jones, and Rossen (1997) analyzed the lexical and gestural abilities of 54 children (30 boys, 24 girls) with WS. Mean age was 34 months (SD = 11.2). In this study, if parents estimated that their child's EV was under 50 words and was not yet combining words the parent was asked to complete the CDI-WG, otherwise the parent reported from the CDI-WS; if the parents were not sure if the child's EV was more than 50 words, they were asked to complete both CDI forms. From this sample, CDI-WG was available for 32 children (mean age 34 months, SD = 11.5). For this group of children mean RV size was 163 words (SD = 111), mean EV size was 61 words (SD = 82), and mean TG was 34 (SD = 14). When EV was compared to the CDI-WG norms for TD children, all children with WS were below the 10th percentile (the lowest percentile considered by Singer-Harris et al.).

In a younger group of children with WS, Mervis and Robinson (2000) analyzed EV size in a group of 24 2-year-olds (mean CA: 2.56 years; SD: .36). EV size was determined from the CDI-WS. The children had a mean EV size of 132.50 words (SD: 112.29; range: 3 – 391 words). Two additional children aged 24 and 25 months had EVs of 412 and 439 words; these children were excluded from the analyses because they were outliers relative to the other young 2-year-olds. These results show a delay and great variability in lexical development in children with WS. Twelve of the 24 children were young enough to compare their vocabulary sizes with the CDI-WS norms. Eight of the children scored below the 5th percentile and the remainder below the 10th percentile for the general population. In contrast, the two outliers scored at the 75th percentile. Variability of EV for children with WS was similar to the variability for the general population.

In a longitudinal study, Mervis, Robinson, Rowe, Becerra, and Klein-Tasman (2003) analyzed age of acquisition of various lexical milestones based on parental report on the CDI-WS and compared these to the CDI-WS norms. Thirteen children with WS started the study when their EV was < 6 words (mean EV size at beginning of the study was 1 word). Age of acquisition of 10-word EV size was below the 5th percentile for all 13 children, and age of acquisition of 50- and 100-word EVs was below the 5th percentile for all but one child. The median CA at acquisition of a 100-word EV was 37 months (range: 26 – 68 months). In contrast, the median for TD children for age of acquisition of 100-word EV is 18 months, and the 5th percentile is at 28 months (Fenson et al., 2007). Further analysis showed that age of acquisition of a 10-word EV was highly correlated with age of acquisition of 50- and 100-word EVs and with onset of novel word combinations (Mervis et al., 2003).

In summary, the CDI is a widely used method for the study of early lexical and gestural development, not only in TD children but also in children with DD. Findings from studies of children with DS, ASD, or WS indicate a significant delay in RV, EV, and gestural development. It is important to note that there are very few studies that have considered early lexical and/or gestural development in very young children with WS. The few studies that have been conducted are characterized by small sample size, very broad age range, or both, which makes it difficult both to generalize the findings to the population of young children with WS and to compare the findings to those for TD children. In the present study I will analyze early lexical and gestural abilities as measured by the CDI in a larger sample of children over a narrower age range. I will include three age groups: 18-month-olds, 24-month-olds, and 30-month-olds. For the 18 month-olds I will compare RV, EV, EG, LG, and TG to the CDI-WG norms, and for the 18-month-olds, 24-month-olds, and 30-month-olds EV will be compared to the CDI-WS norms.

## Relations Between Gestural and Lexical Abilities

Studies of early language development have analyzed the role of gestures in lexical development. These studies have provided substantial evidence that TD children first communicate using gestures before they communicate through words (Bates, 1976; Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979). For example, pointing gestures are used to refer to objects before the child knows the name for the object. Later in development, after children begin to talk, they produce word+gesture combinations to complement their message (e.g., pointing to a cookie when saying "more") before they can produce a two-word utterance (e.g., "more cookie") (Capirci, Iverson, Pizzuto, & Volterra, 1996; Iverson & Goldin-Meadow, 2005). Goldin-Meadow and colleagues (Goldin-Meadow, 2007; Iverson & Goldin-Meadow, 2005) have addressed the question of how gestures are tied to language development. They propose the "Gestural-

Facilitation Hypothesis" which suggest that early in development children communicate through gestures when they cannot communicate verbally.

This theoretical perspective has lead to a vast amount of research on the relation between gestures and lexical abilities in TD children, children with DD (most commonly children with ASD) and a few studies on children with DS or WS. In this section, I will review some of these studies and will provide evidence on why further research should look at this relation in children with WS.

**Relations between Gestures and Lexical Abilities in TD children**

Fenson et al. (1994) studied the correlations among total scores for RV, EV, and TG in the CDI norming sample. Significant correlations were found between RV and TG ($r = .54$, $p<.01$); the partial correlation with age and EV partialled out was .32 ($p<.001$). Correlations between RV and EV were significant ($r = .53$, $p< .001$); the partial correlation with age and gestures partialled out was .39 ($p<.001$). The correlation was also significant between EV and TG ($r = .28$, $p < .01$); however, this correlation was not significant once age and RV were partialled out. These results indicate that gestural abilities are more closely related to receptive vocabulary abilities than to expressive vocabulary abilities. Receptive vocabulary size and expressive vocabulary size are strongly related. Similar results were reported by Bates, Thal, Whitesell, Fenson, and Oakes (1989).

Fenson et al. (1994, p.66) provide a more detailed characterization of the relation between vocabulary comprehension and production. They evaluated the characteristics of EV within the context of RV, as measured by the CDI-WG. Results indicated that for children whose RV was between 21 and 50 words, median EV was 2 words (11 words at 90th percentile); for RV between 51 - 100 words, median EV was 6 words (26 words at 90th percentile); for RV between 101 - 150 words, median EV was 12 words (0 words at 10th percentile, and 39 words at 90th percentile); and for children with RV between 151 - 200 words, median EV is 18 words (4 words at the 10th percentile, 53 words at the 90th percentile). These results provide further characterization of the relation between vocabulary comprehension and production. Individual children's productive vocabulary can be analyzed not only in the context of chronological age but also a deeper analysis and characterization based on expectations given word comprehension abilities.

Volterra et. al. (2005) reported that Caselli and Casadio (1995) found significant correlations between RV, EV, and gestures using the Italian version of the CDI-WG, in a sample of 315 Italian TD children. However, neither the correlation values nor the p-values were reported. They found that early in development children's repertoire of gestures (including deictic and referential gestures, real and pretend actions with objects, and symbolic play schemes) was larger than EV.

In a recent study of Swedish children, using the Swedish version of the CDI (SECDI), Sundvist, Nordqvist, Koch, and Heimann (2016) found a significant longitudinal correlation between RV at 9 months of age and RV at 16 months of age ($r = .55$, $p<.01$). In addition, TG at 9 months of age correlated significantly with RV ($r = .50$, $p<.01$), EV ($r = .46$, $p<.01$), and TG ($r = .64$, $p<.01$) at 16 months of age. The correlation between EV at 9 months of age and EV at 16 months was not significant.

Another line of research to determine the relation between gestures and lexical abilities has focused on videotaped play sessions of the child and the primary caregiver. Iverson and Goldin-Meadow (2005) analyzed the relation between gestures and later lexical development in a group of 10 TD children between the ages of 10 and 24 months. Children were videotaped monthly at home for 30 minutes during a play session with the primary caregiver and a mealtime. The children were observed an average of 8 times. Gestures and speech were coded from the videotaped sessions. Communicative gestures were coded as: (a) deictic gestures: indicate a referent that is immediate in the environment (three types of deictic gestures were considered: showing, index point, or palm point); (b) conventional gestures: culturally defined gestures (e. g. nodding head for "yes"); (c) ritualized reaches: arm extensions to an object, while opening and closing the hand. Lexical abilities were coded from all meaningful vocalizations or patterns of sounds consistently used to refer to an object. Their results showed that initially children communicated about objects through gestures but by the last session they had transitioned to a verbal referent to objects and none of the children was communicating exclusively via gestures. Further analysis showed that on average, children produced a gesture for a particular object 3.0 months before they produced the verbal referent for that object. Iverson and Goldin-Meadow suggest that from these results, they were able to predict which words would be added to a child's vocabulary based on which objects the child referenced using a gestures. In addition, for all children, gesture+word combinations preceded 2-word utterances. Gesture+word combinations were categorized either as supplementary (speech provides a different but related piece of information about the object, e.g. pointing at a cookie while saying “more”) or complementary (speech referring to the object of the gesture, e.g. pointing at a cookie while saying “cookie”). In their sample, mean interval between the production of supplementary gesture+word combinations and two-word combinations was 2.3 months. In contrast, the mean interval between onset of complementary gesture+word combinations and two-word combinations was 4.7 months. Further analysis showed that age of onset of supplementary gesture+word combinations significantly correlated with age at onset of two-word utterances, whereas the age of onset of complementary gesture+word combinations did not correlate significantly with age at onset of two-word utterances. The authors suggested that these results support the theory that gestures facilitate both lexical and grammatical development in children, as they were able to predict a large proportion of spoken vocabulary and two-word combinations from each child’s earlier gestures (Iverson & Goldin-Meadow, 2005).

**Relations between Lexical and Gestural Abilities in Children with Developmental Delay**

Very few studies have analyzed the relations between lexical abilities and gestural abilities in children with DD. These studies have shown that for some groups of children with DD, patterns of correlations are not the same as for TD children. Most of the studies that have analyzed these relations in children with DD used the CDI to measure vocabulary abilities but measured gestural abilities during a play session rather than based on the CDI. In the following review I include a few studies that have taken this approach to determine gestural abilities.

*Down syndrome.* Caselli et al. (1998), in the same study described previously with a sample of 40 Italian children with DS with a mean chronological age of 28.4 months, analyzed possible dissociations between RV, EV, and various gesture measures derived from the CDI in children with DS in comparison to TD children. To determine possible dissociations, they matched each child with DS to a TD child based on RV size. The TD children in this group were part of the norming sample for the Italian version of the CDI (Caselli & Casadio, 1995). When children with DS were matched by RV to TD children, the children with DS produced significantly more gestures. Additional analyses, to compare the differences in gestures produced by the two groups, calculated the percent of deictic gestures, symbolic communicative gestures, games and routines, and imitating adult's actions. Results showed that the children with DS produced more symbolic communicative gestures, pretending gestures, and actions with symbolic transformations (e.g. using a spoon as an airplane) when compared to the TD children matched for RV. No differences were found between the two groups in the number of pointing /showing/requesting gestures. Further analyses divided the children in subgroups based on RV size (0-50, 51-100, 101-200, 201-300, 301-400; note that the Italian version of the CDI has a vocabulary checklist of 408 words). When compared to the TD children within the same range of RV size, no significant differences were found in gesture production for the first two RV intervals, but for the remaining RV intervals, children with DS produced a significantly higher number of gestures in comparison to TD children. No significant differences were found for EV between children with DS and TD children when matched by RV size.

Singer Harris et al. (1997) analyzed the relation between components of the CDI-WG in 28 children with DS and found similar results to those of Caselli et al. (1998). When compared to the dissociation norms for TD children, the EV of children with DS was on average at the 60th percentile given their RV. In addition, when compared to TD children, children with DS on average had significantly more gestures relative to both their level of RV and their level of EV ($p<.0001$). Children with DS were on average at the 77th percentile for gestures relative to TD children at the same RV and at the 80th percentile for gestures relative to EV in comparison to TD children.

An additional study by Zampini and D'Odorico (2011) analyzed the relation between early gestural behavior and later lexical abilities in children with DS. In a sample of twenty 36-month-olds (range: 35.28 – 38.18 months) gestural abilities were determined from a mother-child play interaction. These gestures were classified in three categories: 1) deictic gestures (gestures related to an object in the environment, including pointing, giving, and showing) 2) conventional gestures (culturally defined gestures, e.g., waving bye bye), and 3) iconic gestures (gestures related to the function or characteristics of objects, persons, or events, e.g., pretending to drive a car). Lexical abilities were determined using the Italian version of the CDI (PVB, Caselli, & Casadio, 1995). Significant correlations were found between RV and certain gestural measures from the play interactions: total number of gestures ($r = 0.51$, $p < .05$), number of deictic gestures ($r = 0.50$, $p < .05$), and number of conventional gestures ($r = .45$, $p < .05$). No significant correlations were found between gestural behaviors from the play interaction and EV. This same pattern of correlations between gestures and RV and gestures and EV was found by Caselli and Casadio (1995) for TD children, with gestures correlated with receptive vocabulary but not with expressive vocabulary.

*ASD.* Charman et al. (2003) analyzed the correlations among lexical abilities and gestures, as measured on the CDI-WG, in children with ASD. A significant correlation was found between RV and EV ($r$= 0.45, $p$<0.001). In addition, significant correlations between TG and both RV and EV ($r$=0.71, and $r$= 0.49, respectively, $p$<0.001) were found. Further analyses showed that the partial correlations between RV and gestures, when nonverbal mental age and EV were partialled out, was still significant ($r$= 0.54). The same was true for the relation between RV and EV, when nonverbal mental age and gestures were partialled out ($r$= 0.50). On the other hand, when nonverbal mental age and RV were partialled out, the partial correlation between EV and gestures was not significant ($r$ = -0.04). An additional analysis showed that this pattern of correlations was not specific to early or late gestures from the CDI-WG. These results show a similar pattern of relations between gestures and expressive vocabulary in children with ASD as was found in previous studies for TD children (Fenson, et al., 1994).

In addition, Charman et al. (2003) analyzed possible dissociations between RV and EV by comparing their sample of children with ASD to the dissociation norms for TD children (Fenson et al., 1994). When EV size was analyzed in the context of RV in children with ASD, results showed that for children with ASD the developmental trend is similar as in TD children, but children with ASD produced more words than TD children for a given RV interval (with the exception of RV size between 0 – 20 words). They found that at 21-50 words of RV, mean EV was 7 (median of 2 in TD children); at 51 -

100 words of RV, mean EV was 13 (median of 6 for TD children); at 101 - 150 words for RV, mean EV was 38 words (median of 12 for TD children), and at 151 - 200 mean words of RV, mean EV size was 48 words (median of 18 for TD children). The comparisons between children with ASD and TD children have to be interpreted with caution, because the authors reported means for EV and the norms provide percentile ranks (median). Nonetheless, it is important to acknowledge this study because it is one of the few that analyzed possible dissociations among receptive and expressive vocabulary sizes in children with DD, and the only one for children with ASD.

Charman et al. (2003) conducted additional analyses to compare gestural abilities in the context of RV for children with ASD. Table 2 shows the results for number of gestures produced for each RV interval.

Table 2

*Descriptive Statistics for Number of EG, LG and TG by RV size.*

| | | Gestural Abilities[1] | | |
|---|---|---|---|---|
| | | EG *M* (SD) | LG *M* (SD) | TG *M*(SD) |
| RV Size | 0 - 20 words (n = 23) | 3.9 (2.2) | 8.4 (6.4) | 13.3 (8.3) |
| | 21 - 50 words ( n = 23) | 7.9 (3.0) | 19.2 (3.0) | 27.6 (9.8) |
| | 51 - 100 words (n = 15) | 7.7 (2.7) | 21.1 (7.9) | 29.6 (9.8) |
| | 101 - 150 words (n = 21) | 8.0 ( 3.6) | 19.7 (7.3) | 27.9 (9.9) |
| | 151 - 200 words (n = 19) | 10.9 (3.6) | 25.7 (7.7) | 38.0 (9.4) |

[1]Maximum = 18 for EG, 45 for LG, and 63 for TG

These results showed that growth in LG is largely responsible for the growth in TG as level of RV increases. Growth in EG tends to remain flat after RV reaches 50 words. Unfortunately, the authors did not report percentile ranks for gestural abilities within each of the RV intervals, which would have provided information on how these abilities compare to the CDI norming sample.

*Williams syndrome.* To date, very few studies have analyzed the relation between RV, EV and gestures in children with WS. Singer Harris et al. (1997), in an additional analysis beyond those reported in the previous section, considered the relations between components of the CDI-WG. In a group of 34 children with WS (mean CA: 34 months, SD = 11), they studied three dissociations: 1) EV given the child's RV size, 2) TG given the child's RV, and 3) TG given the child's EV size. When children with WS were compared to the dissociation norms for TD children, EV was on average at the 63rd percentile in the context of RV. With regard to TG, children with WS were on average at the 55th percentile when compared to TD children in the context of both RV size and EV size. These results suggest that gestural abilities follow the same relation with RV and EV as has been determined for TD children.

A second longitudinal study by Mervis and Bertrand (1997) analyzed the relation between early lexical development and gestural development in children with WS. Their study included 10 children with WS who participated with their parents in monthly play sessions. Additionally, the parents completed the CDI (Fenson et al. 1993). The children entered the study between the ages of 4 months and 26 months. Previous research suggests that in TD children and children with DS, referential pointing is acquired prior to production of first referential words (e.g., Adamson, 1995). Mervis and Bertrand (1997) analyzed the sequence of development between referential pointing and referential object labeling in individuals with WS from the play sessions and from parental report on the CDI. Of the 10 children in their study, 9 began to produce referential object labels before they comprehended or produced referential pointing. The remaining child, who had the most severe developmental delay of any of the children in the sample, comprehended and produced referential pointing shortly before he began to produce referential labels. Results from the study indicated that the relation between early lexical development and early deictic gestural development in children with WS is not the same as for TD children. In particular, TD children first express their intentions gesturally by pointing and then verbally by labeling. In contrast, children with WS first express their intentions verbally by labeling before they are able to express them gesturally by pointing.

Laing et al. (2002) used cross-sectional methodology to analyze the development of joint attention and pointing in children with WS in relation to RV and EV. Their first study included a sample of 13 young children with WS (mean CA, 31 months; range: 17 months – 55 months) matched for mental age to a group of 13 TD toddlers (mean CA, 13.5 months; range: 5 – 22 months). Mean mental age (MA) for the WS group was 14 months (range: 6 – 23 months). Based on parental report from the CDI, mean EV was 56 words (SD = 83.3) for the WS group and 31.5 words (SD = 53.2) for the TD group. Mean RV was 116.2 words (SD = 101.6) for the WS group and 110.3 words (SD = 89.5) for the TD group.  Children were assessed using the Early Social Communication Scales (ESCS, Mundy & Hogan, 1996), which measures initiation of joint attention, response to joint attention, initiation of request, response to request, and social interaction. Results showed that children with WS were significantly less likely to initiate a request ($p<.05$) and less likely to initiate joint attention ($p=.07$) but more likely to engage in dyadic (as opposed to triadic) social interaction than the TD children.

Laing and colleagues (2002) analyzed the relation between RV and EV (as measured by the CDI) and the variables from the ESCS. Both RV and EV were significantly related to response to joint attention for both the WS group and the TD group. None of the other measures from the ESCS was significantly correlated with RV or EV for either group.

In general, significant correlations have been found between lexical and gestural abilities during early development. These studies support the theory that gestures play a transitional role in the acquisition of early lexical abilities for TD children and children with DD (Iverson & Goldin-Meadow, 2005). In TD children and children with DS gestural abilities appear to be more closely related to RV than to EV (Caselli & Casadio, 1995; Fenson et al., 1994). Analyses with children with WS are inconclusive. It has been shown that for children with WS, the relation between the onset of referential gestures and the onset of referential labeling does not follow the same trajectory as for TD children and children with DS. However, findings from Singer Harris et al. (1997) suggest that if the measure of gesturing is not restricted to deictic gestures, the relation of both RV and EV to the number of different gestures (TG) is similar to that expected for TD children. Further analysis needs to be done to address these relations in young children with WS. In the present study, I will analyze concurrent relations between RV, EV, EG, and LG and between RV, EV, and TG for three age groups: 18 months, 24 months, and 30 months. To further study the relation between gestures and lexical abilities, I will look at the correlation between age of onset of deictic gestures and EV size at the time of onset of deictic gestures. In addition, considering dissociation norms on the CDI-WG I will determine characteristics of EV given RV size, TG given EV size, and TG given RV size in a large sample of children with WS.

## Early Lexical and Gestural Abilities as Predictors of Later Development

Studies of various groups of children have looked at the predictive value of early gestural and lexical abilities for later cognitive and language abilities. These studies are particularly important because of their theoretical and clinical implications. From a theoretical perspective, these studies provide evidence for the continuity between very early development of gestures and lexicon and language and cognitive abilities at later stages in childhood development (Watt, Wetherby, & Shumway, 2006). From a clinical perspective, these studies are important to determine intervention goals during early stages of development.

To date, studies have analyzed the predictive validity of early language and gestural abilities for later language and intellectual abilities in various groups of children, including late talkers (Rescorla, 2003), preterm infants (Luu et al., 2009; Perez-Pereira, Fernandez, Gomez-Taibo, & Resches, 2014; Stolt et al., 2014) children with very low birth weight (VLBW; Stolt, Lind, Matomaki, Haatja, Lapinleimu, & Lehtonen, 2016) as well as for TD children or children with various types of DD. Below I review the available studies in TD children and children with DD.

**Early Lexical and Gestural Abilities as Predictors of Later Development in TD Children**

One of the first studies to analyze the predictability of later development from parental-report measures of early language was conducted by Bates, Bretherton, and Snyder (1988, cited in Bornstein & Haynes, 1998). Bates et al. determined that parental report of RV at 10 months and 13 months of age predicted language comprehension at 28 months as measured by the Peabody Picture Vocabulary Test-Revised (PPVT-R; Dunn & Dunn, 1981). Bornstein and Haynes (1998) studied the relation between early lexical abilities and later intellectual and vocabulary abilities. Early lexical abilities were measured by the 643-word vocabulary checklist on the Early Language Inventory (ELI; Bates et. al. 1988). The ELI is a precursor to the CDI-WS, and 81% of the words on the CDI-WS were included in the ELI. In their sample of 154 English-speaking TD toddlers (97 boys and 90 girls) EV was determined at 20 months of age. Intellectual abilities at 48 months of age were measured by the Wechsler Preschool and Primary Scale of Intelligence-Revised Edition (WPPSI-R; Wechsler, 1989) and Verbal IQ and Performance IQ were determined. Correlation analyses showed significant relations between EV at 20 months and Verbal IQ and Performance IQ at 48 months ($r = 0.35$, $p < .001$, and $r = .18$, $p < .05$ respectively).

Reese and Read (2000) studied the predictive validity of the New Zealand version of the CDI-WS (NZCDI-WS) for later lexical abilities. In their sample of 61 TD children, EV was tested at 1;7 years (1 year 7 months; T1) and at 2;1 (T2) years based on the NZCDI-WS. Later vocabulary abilities were tested at 2;8 (T3) and 3;4 (T4) years using the PPVT-III (receptive vocabulary, Dunn & Dunn, 1997) and EVT (expressive vocabulary, Williams, 1997). Significant correlations were found between EV at T1 and T2 with both PPVT-III standard scores and EVT standard scores at both T3 and T4. All *r*s were between 0.43 and 0.50 ($p < 0.01$). No differences between the correlations with the EVT and the PPVT-III were found. These studies provide evidence that EV at early ages relates to both later expressive vocabulary and later receptive vocabulary.

Feldman and colleagues (Feldman et al., 2005) analyzed the predictive validity of the CDI-WS in a sample of 113 English-speaking TD children. EV was determined at 2 years of age from the CDI-WS. At 3 years of age intellectual abilities were determined from the McCarthy Scales of Children's Abilities (McCarthy, 1972) and receptive vocabulary was determined from the PPVT-R (Dunn & Dunn, 1981). Significant correlations between EV at 2 years and measures of intellectual ability and receptive vocabulary at 3 years were found: between EV and McCarthy-General Cognitive Index, $r = .38$ ($p<.001$); between EV and McCarthy Verbal standard score, $r = .37$ ($p<.001$); and between EV and PPVT-R standard scores $r = .32$ ($p<.001$). Further analysis showed that CDI-WS EV had a fair to good sensitivity for prediction of language and cognitive delay at 3 years of age.

A series of longitudinal studies of TD children has focused primarily on the role of early gestures in predicting later language learning (Rowe & Goldin-Meadow, 2009; Rowe, Ozcaliskan, & Goldin-Meadow, 2008). Parent-child dyads were visited at home every 4 months beginning at 14 months of age. During the home visits a 90-minute session was videotaped; the session included toy play, book reading, and snack or meal time.

In the first study, Rowe et al. (2008) analyzed how gestures at 14 months of age predict later receptive vocabulary abilities, as measured by the PPVT-III (Dunn & Dunn, 1997) at 42 months. In their sample of 53 children gestural abilities were determined from the videotaped sessions. Gestures were coded as deictic gestures (pointing to object, person, or location in the environment), representational gestures (representations of actions of attributes of concrete or abstract referents, e.g. moving arms in front of the body as if driving), and conventional gestures, (culturally determined gestures, e.g. nodding head as "yes"). Four measure of gestures were calculated: gesture tokens (total number of gestures the child produced) gesture types (number of semantic categories conveyed in gestures, or "gesture vocabulary" [p. 187], proportion of gesture+word productions out of all gesture productions, and proportion of gesture-only productions out of all gesture productions. Their result showed that three of the four child gesture measures at age 14 months were significantly related to PPVT-III standard scores scores at 42 months after controlling for word types at 14 months. In particular, after controlling for word types at 14 months, PPVT-III standard scores at 42 months significantly correlated with gesture tokens ($r = 0.41$, $p<.01$), with gesture types ($r = 0.52$, $p<.01$), and with proportion of gesture+word productions out of total gesture productions ($r = 0.38$, $p<.01$). No significant correlation was found with proportion of gesture-only productions. Multiple regression analysis showed that child gesture types at 14 months was the best predictor of receptive vocabulary at 42 months. In the regression model, when controlling for word types, gesture types accounted for approximately 32% of the variance in PPVT-III standard scores at 42 months ($\beta= 0.80$, $p<0.001$). Rowe et al. (2008) also analyzed environmental characteristics as possible predictors of PPVT-III standard scores. When parent education, parent age, birth order, and gender were introduced in the regression models, parent education explained an additional 5% of the variance in PPVT-III standard scores at 42 months, after controlling for child word types, child gesture types and parent word types at 14 months.

In a second study, with children from the same longitudinal study as described above, Rowe and Goldin-Meadow (2009) analyzed the predictive value of two different gesture measures at 18 months of age for receptive vocabulary at 42 months as measured by the PPVT-III (Dunn & Dunn, 1997). Two types of gesture abilities were determined from the videotaped play session: gesture vocabulary (number of different meanings expressed via gestures) and gesture+word combinations. At 18 months of age, children had an average of 33.6 gesture vocabulary types (SD = 21.8) and a mean of 11 gesture+word combinations (SD = 11.4). In addition, expressive vocabulary size from word counts during the videotaped sessions was determined. At 18 months of age, children produced a mean of 40 different words (SD = 0.16). Multiple regression analysis showed that spoken vocabulary explained 16.7% of the variation of PPVT-III standard scores at 42 months of age ($\beta = 0.41$, $p < .01$). When gesture vocabulary was included in the model as an additional predictor, gesture vocabulary was a strong predictor ($\beta = 0.40$, $p < .01$) and spoken vocabulary was reduced in strength of the prediction, although still accounting for a significant amount of variance ($\beta = 0.28$, $p < .05$). Together, gesture vocabulary and spoken vocabulary accounted for 30.9% of the variation in PPVT-III scores at 42 months of age.

A series of studies has analyzed the predictive value of RV, EV, and gestures in preterm children or children with VLBW (Perez-Pereira et al., 2014 and Stolt, et al., 2014). Stolt et al. (2016) in a group of 25 VLBW children, studied RV, EV and gestures at ages 9 months, 12 months, 15 months, and 2 years, determined from the Finnish version of the CDI-WS (FinCDI, Lyytinen, 1999). They analyzed the correlation of early EV and gestural abilities to later language abilities at 5 years of age measured by the Nepsy-II (Nepsy-II-L;Korkman, Kirk, & Kemp, 2007) and the Boston Naming Test (BNT; Kaplan, Goodglass, & Weintraug, 1983; Laine et al., 1993). Significant correlations were found between TG at 9, 12, and 15 months of age and NEPSY-II-L scores at 5 years of age ($r = 0.40$, $p<.05$; $r = 0.45$, $p<.01$; and $r = 0.42$, $p<.05$ respectively for each of the TG ages). In addition, significant correlations were found between EV at 2 years and both NEPSY-II-L standard score and expressive vocabulary ability as measured by the BNT at 5 years of age.

These studies that have been conducted with TD children and children who were premature and/or very low birth weight provide evidence of significant correlations among early gestures and lexical abilities and later development. In the following section, I will describe the studies that have looked at these correlations and the predictive value of early lexical and gestural abilities in children with DD.

**Early Lexical and Gestural Abilities as Predictors of Later Development in Children with Developmental Delay**

*Down syndrome.* Zampini and D’Odorico (2011) analyzed the relation between early gestural behavior and later lexical abilities for a sample of 20 children with DS.

Gestural abilities were determined from a mother-child play interaction at age 36 months. As described previously, these gestures were classified in three categories: 1) deictic gestures, 2) conventional gestures, and 3) iconic gestures. Lexical abilities at 36 and 42 months were determined using the Italian version of the CDI (PVB; Caselli, & Casadio, 1995). Partial correlations between various measures of gesture production at 36 months and EV as measured by the PVB at 42 months were significant. The strongest correlations were between the number of gestures produced in association with looks directed to the mother ($r = 0.71$, $p < 0.001$) and EV at 42 months and the number of deictic gestures with looks to the mother ($r = 0.70$, $p < 0.001$) and EV at 42 months. These results indicate that early gestures may predict later EV in children with DS.

*Autism Spectrum Disorder.* Most of the studies that have analyzed the predictive value of early gestural and lexical abilities in children with DD have focused on children with ASD. Luyster, Qui, Lopez, and Lord (2007), in a sample of 49 children with ASD, analyzed the predictive validity of RV size, early gestures, and late gestures (from the CDI-WG) and presence of expressive words (which was a binary variable coded as yes/no) at 2 years of age (mean 29.02 months, SD = 4.34) with intellectual and language abilities at about 9 years of age (mean 123.64 months, SD = 9.52). Expressive and receptive language abilities at age 9 were evaluated by different methods depending on the developmental level of the child. For the majority of children, the Sequenced Inventory of Communication Development-Revised (Hedrick, Prather, & Tobin, 1984) was used, but language scores were based on the Clinical Evaluation of Language Fundamentals (CELF-P; Wiig, Secord, & Semel, 1992) for 13 children, the Vineland

Adaptive Behavior Scales (VABS, Sparrow, Cicchetti, & Balla, 2005) for 10 children, and the Reynell Developmental Language Scales (Reynell & Gruber, 1990) for 10 children. Multiple regression analysis showed that CDI RV and EV accounted for a significant amount of variance in expressive language at 9 years. In addition, LG significantly predicted verbal IQ, expressive language, and adaptive behavior as measured by the VABS (the authors do not report type of scores used for this analysis). These results are difficult to interpret due to the fact that many disparate measures were used to determine language abilities at 9 years.

Smith, Mirenda, and Zaidman-Zait (2007) studied the development of EV in a sample of 35 children with ASD over a 2-year period. Mean age at the start of the study was 45.59 months (range: 20.50 – 67.60 months). All children had an EV size of less than 60 words (CDI-WG) at the start of the study. Children were visited at home four times, with an average of six months between the first three visits and 12 months between the third and fourth visits. Intellectual abilities at baseline were determined from the Mullen Scales of Early Learning (MSEL, Mullen, 1995). The MSEL yields a measure of intellectual ability (ELC, similar to IQ) with a mean of 100 and SD=15 for TD children. In addition, severity of autism behavior was measured through the Childhood Autism Rating Scale (CARS, Schopler et al., 1988). During subsequent visits EV abilities were determined from either the CDI-WG or the CDI-WS. If the parent indicated that the child had an EV higher than 50 words parents would report from the Vocabulary Checklist of the CDI-WS. Cluster analysis of rate of vocabulary growth identified four groups. The first group (n=15) had a flat EV growth, with a mean increase of EV in 2 years of 9.74 words (range:

0 – 56 words). The second group (n=8) had a slow increase in EV especially between the 12- and 24-month follow up period. EV increased a mean of 220.25 words (range = 139 – 314 words). The children in the third cluster (n=7) produced few words at the first session with a later high and steady increase in EV. Mean EV increase during the 2 years of follow up was 453.43 words (range = 399 – 620 words). The fourth cluster (n=5) was characterized by a very steep rate of EV growth. Mean increase of EV abilities during the 2 years was 638 words (range = 646 – 697 words). After determining the four clusters based on rate of EV growth, further analysis was done to determine possible predictors based on measures taken at baseline. No significant differences were found for chronological age, ELC, or CARS scores at baseline between the four clusters. Significant differences were found with regard to EV size at baseline between the clusters ($F$ (4,30) = 6.42, $p<.002$). Post hoc comparisons showed significant differences between cluster 1 and cluster 3 ($p = .01$) and cluster 1 and 4 ($p = .002$). In addition, the authors analyzed differences between the clusters in gestural abilities from the CDI-WG at baseline. Authors measured Initiation of Joint Attention (IJA) based on parental response to the give, show, and point items from the First Communicative Gestures, awarding 1 point for each of the behaviors that the child demonstrated. Further analysis showed significant differences in IJA at baseline between the clusters, $F(4,30) = 3.39$, $p =.03$. Post hoc analysis showed significant differences between cluster 1 and cluster 4 ($p=.02$), and between cluster 2 and cluster 4 ($p=.02$). No differences were found between the clusters' LG abilities at baseline. This study suggests that rate of EV growth can be predicted by a child's early IJA behavior. Other gestural abilities did not significantly

affect children's rate of EV acquisition. Interestingly, neither CA at the start of the study, ELC, nor severity of autism behaviors as measured by the CARS significantly affected rate of EV growth over the period of 2 years.

In a recent study, Ozcaliskan, Adamson, and Dimitrova (2015) analyzed how gestures predict later vocabulary in a group of 23 children with ASD (mean age at the start of the study = 31 months; range: 21 – 37 months). Gestural and EV abilities were determined from a 20-minute parent-child videotaped session following the Communication Play Protocol (CPP; Adamson et al., 2009). Gestures were defined as a communicative hand or body movement that was directed to the parent but that did not include manipulation of an object. Gestures were coded into five types: (1) deictic gestures (indicated referent by either pointing or showing), (2) "give" gestures, (3) conventional (culturally defined gestures), (4) iconic (gestures that refer to an object based on its action or feature, e.g. moving arms as if driving), and (5) beats (gestures that accompanied speech, but without a semantic meaning). Language was determined from the words children produced during the videotaped sessions. Two types of language measures were determined: (1) word tokens (total number of words), (2) word types (total number of different words). Vocabulary ability one year later was measured using the Expressive Vocabulary Test standard score (EVT; Williams, 1997). A significant correlation between number of deictic gestures and EVT standard score was found ($r = 0.72$, $p = 0.001$). On the other hand, no significant correlations were found between either give or conventional gestures and later expressive vocabulary ($r = 0.20$, $p = 0.43$ and $r = -0.03$, $p = 0.92$). Similar correlations were found for a group of TD children matched on word tokens and word types. Ozcaliskan et al. (2015) argue that these results suggest that pointing and showing, used to capture the attention of the communicative partner, predicted later expressive vocabulary in children with ASD. Deictic gestures are used by children as means for referring to an object before the child can say the verbal referent to the object. The authors in the study report correlation analysis between gestural measures and EVT scores. Therefore, the argument of the predictive value of deictic gestures to later expressive vocabulary abilities should be interpreted cautiously.

Smith et al., (2007) and Ozcaliscan et al. (2015) show that early deictic gestures in children with ASD relate to later expressive vocabulary abilities. Smith et al. (2007) show that children who at the beginning of the study were producing deictic gestures differ significantly in the rate of EV development to the children who were not. Children who were producing deictic gestures had a steep vocabulary growth, whereas the children who were not tended to have a flat growth curve. Ozcaliscan et al. (2015) show a significant correlation between number of deictic gestures and later expressive vocabulary as measured by the EVT.

*Williams syndrome.* Most studies of lexical abilities in children with WS have been cross-sectional. Very few studies have analyzed the relations between early language abilities and later language and intellectual abilities in children with WS. A longitudinal study of early language development of 23 children with WS for whom CDI data were collected monthly provides additional evidence for the relation between lexical development and cognition, based on the shape of the curve for EV growth (Mervis, 2004; Mervis et al., 2003). The EV of 20 of the 23 children followed a logistic growth curve (the form of EV growth shown by TD children; Robinson & Mervis, 1999). Two children evidenced slow linear growth until at least five years of age. One child showed a growth pattern characterized as "double linear."

To determine if growth curve type was related to later cognitive abilities the standard scores from standardized tests were compared for the three sets of children at age 48 months (Mervis, 2004; Mervis et al., 2003). The logistic growth group earned significantly higher standard scores on the PPVT-III (receptive vocabulary), the Preschool DAS (Elliott, 1990) GCA (similar to IQ), Verbal cluster, and Nonverbal cluster, and had a significantly longer Forward Digit span than the linear growth group. There was almost no overlap between the standard scores for the two groups. The child with the double-linear growth curve scored in between the other two groups. These results suggest that the shape of early EV growth is related to later verbal short-term memory, nonverbal cognition (including visuospatial construction), as well as to other measures of language development for children with WS.

An additional analysis considered the relation between age of acquisition of various language milestones and later intellectual abilities at 4 years of age in an overlapping sample of 22 children with WS (Becerra, Henderson, John, & Mervis, 2010; Mervis & John, 2012). Based on parental report on the CDI-WS, age of acquisition of 10-word, 50-word, and 100-word EV and first novel word combinations were strongly correlated with intellectual abilities as measured by the DAS [GCA, Verbal cluster standard score, Nonverbal cluster standard score] at 4 years of age. All of the correlations were significant (*rs* $\geq .65$). Further analysis showed age of acquisition of a 10-word EV was highly correlated with the other early language milestones (50 words, 100 words, and novel word combination) (all *rs* $\geq$ .88).

### Relation of Maternal Education to Child Intellectual and Language Abilities

The relation of maternal education level to child intellectual abilities has been considered in children in the general population and children at risk due to low birth weight or preterm birth. Most studies found a significant effect of maternal education on Verbal IQ, with higher scores for the children in the higher maternal education group than in the lower maternal education group. In some studies, with very large samples, a significant effect of maternal educational level on child Performance IQ or Full Scale IQ also was found (see Mervis, Kistler, John, & Morris, 2012 for a review). In addition, as described earlier in this chapter, Rowe et al. (2008) found that maternal education was a significant predictor of child receptive vocabulary as measured by the PPVT-III. Mervis et al. (2012), in a group of 40 children with WS who were followed longitudinally, found a significant effect of maternal education level (measured dichotomously, as not having vs. having a bachelor degree) on child Verbal IQ as measured by the Kaufman Brief Intelligence Test-Second Edition (KBIT-2, Kaufman & Kaufman, 2004). Maternal education was not significantly related to Nonverbal IQ or Composite IQ as measured by the KBIT-2.

### Summary

In summary, research on early lexical development in children with WS has shown that early lexical abilities are delayed for most children. Even though there is substantial evidence for these delays, there is still a need to analyze the extent and variability of these delays in a larger sample of children with WS within more narrow age groups. In addition, further research is needed to study early gestural development in children with WS.

Studies on early language development have shown a relation between gesture development and lexical development for both children in the general population and children with various types of DD. Previous research has shown that individuals with WS do not always show the same patterns of relations between expressive and receptive vocabulary or between gestural and language development as have been found for TD children or children with other types of DD. Therefore, further investigation is needed to determine the relation between receptive and expressive vocabulary and between vocabulary abilities (receptive or expressive) and gestural abilities in a large sample of children with WS.

Studies of children in the general population show that early expressive vocabulary correlates with later receptive and expressive vocabulary and later intellectual abilities. In children with WS, two studies have shown a significant predictive value based on the growth patterns of EV and from age of achievement of EV milestones to later intellectual abilities and receptive vocabulary. Early deictic gestures have been shown to be important for early lexical development of both children in the general population and children with DD. Previous research on children with WS suggests that gesture development follows a different pattern relative to lexical development than for TD children or children with DS. It is not clear how this different pattern of relations between gesture development and lexical development might affect language and/or intellectual abilities. In the present study I will determine the correlation and predictive validity of early gestural and lexical abilities to later vocabulary and intellectual abilities in a group of children with WS who are part of a longitudinal study. I also will consider the effect of maternal education level on the development of intellectual and vocabulary abilities in children with WS.

## The Present Study

The purpose of this dissertation project was to describe and analyze early gestural and lexical development in a large sample of children with WS. To do so, I performed three sets of analyses. In the first set, compared early gestures and lexical abilities of 18-month-old children with WS to same aged children in the CDI norming sample. In the second set, analyzed the concurrent relations between early gestural development and early lexical acquisition in very young children with WS. In the third set, addressed the predictive value of individual differences in these early gestural and lexical abilities for individual differences in later intellectual and vocabulary abilities. My research questions for this dissertation project were as follows:

1. **How do the early gestural and lexical abilities of 18-month-old children with WS compare to those of 18-month-old TD children?**

I performed a descriptive analysis of early gestural and lexical abilities of children with WS based on parental report on the MacArthur-Bates Communicative Development Inventory: Words and Gestures (CDI-WG). The CDI-WG provides norms for gestural development (early gestures, late gestures, and total gestures) and lexical development (receptive and expressive vocabulary, based on a 396-word checklist). I compared the performance of individual children with WS on these five measures to the CDI-WG norms for 18-month-old children. The MacArthur-Bates Communicative Development Inventory: Words and Sentences (CDI-WS) also provides norms for expressive vocabulary size for 18-month-olds, based on a vocabulary checklist containing 680 words. I also compared the expressive vocabulary performance of the children with WS to the CDI-WS norms for 18-month-old children.

**2. How do concurrent gestural and lexical abilities relate to each other during early development of children with WS?**

I performed a cross-sectional analysis of the correlations among gestural abilities (early gestures, late gestures, and total gestures) and lexical abilities (receptive and expressive vocabulary size). Gestural abilities were measured by the CDI-WG and lexical abilities by the CDI-WS. Separate analyses were performed for children aged 18, 24, and 30 months.

CDI-WG provides dissociation norms for relations among the various components of the measure. These dissociation norms provide percentile rankings for gestural abilities relative to receptive vocabulary size and also relative to expressive vocabulary size. To further address the question of the relation between gestural and lexical abilities, I examined associations between gestural abilities and receptive vocabulary size and between gestural abilities and expressive vocabulary size for the vocabulary sizes included in the dissociation norms.

Dissociation norms are also available for percentiles for expressive vocabulary size based on children's receptive vocabulary size. I compared associations between expressive vocabulary size and receptive vocabulary size for the receptive vocabulary sizes included in the dissociation norms.

**3. Do early gestural and lexical abilities of children with WS predict later intellectual and vocabulary abilities?**

In order to address this research question, I performed three sets of analyses. First, to determine if gestural and lexical abilities at 18 months of age predict gestural and lexical abilities at 30 months, I computed the correlations among early gestures, late gestures (as measured by the CDI-WG), receptive vocabulary size, and expressive vocabulary size (as measured by the Vocabulary Checklist of the CDI-WS) at 18 months of age with early gestures, late gestures, expressive vocabulary size, and receptive vocabulary size at 30 months of age.

Secondly, I analyzed the correlation between the age of onset of deictic gestures and lexical abilities at 48 months of age. For this analysis, I determined, based on parental report on the CDI-WG, the age of onset for three deictic gestures (give, show, and point). I computed correlations between age of onset of each of the three deictic gestures and expressive vocabulary size at 48 months of age as measured by the Vocabulary Checklist of the CDI-WS.

The third set of analyses determined if language and/or gestural abilities at 24 months of age predict intellectual and vocabulary abilities at 4 years for children with WS. Gestural and early lexical abilities at 24 months of age were determined based on parental report on the CDI. Deictic gestural abilities at 24 months were determined based on parental report from the CDI-WG, and expressive vocabulary size at 24 months was determined from the Vocabulary Checklist of the CDI-WS. In addition, the effect of maternal education level on intellectual and vocabulary abilities at 4 years of age was addressed. Intellectual abilities at 4 years of age were determined from standard scores (SS) on the Differential Ability Scales-II (DAS-II; Elliott, 2007) and vocabulary abilities were determined from SSs on the Peabody Picture Vocabulary Test-4 (PPVT-4, Dunn & Dunn, 2007), a measure of receptive vocabulary, and the Expressive Vocabulary Test-2 (EVT-2, Williams, 2007), a measure of expressive vocabulary.

# CHAPTER II

# LEXICAL AND GESTURAL ABILITIES OF 18-MONTH OLD CHILDREN WITH WS

The onset of language development is delayed for almost all children with WS (Mervis & Robinson, 2000; Mervis, Robinson, Rowe, Becerra, & Klein-Tasman, 2003; Mervis & Becerra, 2007). To date very few studies have included very young children with WS and a large sample size. Only one study looked at gestural abilities in older children with Williams syndrome (Singer-Harris et al., 1997).

The aim of Study 1 was to determine the gestural and lexical abilities of 18-month-old children with WS based on parental report on the CDI-WG and CDI-WS. In addition, gestural and lexical abilities of children with WS were compared to 18-month-old TD children based on the norms for the CDI-WG and CDI-WS.

The second aim of Study 1, was to determine the long term implications of the lexical and gestural characteristics at 18 months of age. This study considered the relation of gestural and lexical abilities at 18 months of age to gestural and lexical abilities at 30 months of age.

## Method

### Participants

All participants in the studies in this chapter are part of an ongoing longitudinal study of early language and intellectual abilities in children with WS, conducted by Dr. Carolyn B. Mervis at the Neurodevelopmental Sciences Laboratory at the University of Louisville. Forty-nine 18-month-old children with WS participated in the study. The mean age of the participants was 18.50 months (SD = .30) and the median age was 18.53 months. The children ranged in age from 18.00 months to 18.96 months

### Measure

### MacArthur-Bates Communicative Development Inventories (CDI; Fenson et al., 1993, 2007)

Lexical and gestural abilities were determined using the MacArthur-Bates Communicative Development Inventory: Words and Gestures (CDI-WG) and the MacArthur-Bates Communicative Development Inventory: Words and Sentences (CDI-WS). The CDI is a widely used and reliable parental report measure of early language development. The CDI-WG measures gestural and lexical abilities for 8 – 18-month-old children. The CDI-WS measures lexical and grammatical abilities for 16 – 30-month-old children. In this study only measures of lexical abilities will be considered.

The 680-word MacArthur-Bates Communicative Development Inventory Words & Sentences (CDI-WS) Vocabulary Checklist, modified to address both receptive and expressive vocabulary, was used to obtain parental report of the child's lexicon. (Note that the CDI-WS Vocabulary Checklist includes the 396 words from the CDI-Words &

Gestures [CDI-WG] Vocabulary Checklist.) The vocabulary checklist is organized into 21 semantic categories. Of these categories 10 are names of objects or people (i.e. animals, vehicles, toys, food and drink, clothing, body parts, furniture and rooms, small household items, outside things and places to go, and people). The remaining categories include sound effects and animal sounds, games and routines, action words, words about time, descriptive words, pronouns, question words, prepositions and locations, quantifiers, helping verbs, and connecting words.

The Early Communicative Checklist (ECC) from the CDI-WG was used to measure early gestural development. The ECC, focuses on the child's use of communicative and symbolic actions and gestures. Parents report which items on the list of 63 gestures their child has produced spontaneously. The 63 gestures are organized into five categories. The 12 items in the first section, First Communicative Gestures, address the onset of intentional communication. This section includes the deictic gestures of giving, showing, and pointing as well as some other communicative gestures that usually are acquired early in development (e.g., waving bye-bye or shaking the head "no"). The 6 items in the second section, Games and Routines, address early social interaction (e.g., singing, playing peekaboo, dancing). The 17 items in the third section, Actions with Objects (e.g., eating with a spoon or fork, putting a telephone to the ear, throwing a ball, brushing teeth), and the 15 items in the fourth section, Imitating other Adult Actions (e.g., pretending to drive a car, cleaning with a cloth, digging with a shovel, watering plants), measure the child's ability to use objects according to their standard functions. The 13 items in the last section, Pretending to be a Parent, include symbolic gestures (e.g., putting a doll or stuffed animal to bed, talking to it, feeding it). Taken together, the 18 items in the first two sections compose the Early Gestures component (EG) which measures gestural communication. The Later Gestures component (LG) includes the 45 items in the last three sections, which measure primarily symbolic behavior, including symbolic play. The Total Gesture component (TG) includes all 63 items.

The CDI-WG was normed in 1089 children (544 girls, 545 boys) and the CDI-WS was normed in 1461 children (728 girls, 733 boys). The norming sample included children from various ethnic backgrounds, maternal education levels, birth order, and from various locations around the United States. The CDI has been tested for content validity (Dale, 1996), concurrent validity (Dale 1990, 1991), and predictive validity (Bates et al., 1988) Feldman et al., 2005). In addition, the CDI has been evaluated for internal consistency and test-retest reliability (Fenson, et al., 2007)

The CDI manual (Fenson et al., 2007) provides normative data based on percentile rankings (Fenson, et. al., 2007). For the CDI-WG percentile rankings are available for 1-month intervals from age 8 months through age 18 months for RV size, EV size, EG, LG, and TG. The norms in the CDI-WG manual provide percentiles from the 5$^{th}$ to the 95$^{th}$ in 5-percentile intervals. The CDI-WS norms provide percentile rankings by age (16-30 months, in 1-month intervals) for EV size (Fenson et. al., 2007). The norms in the CDI-WS manual provide percentiles from the 5$^{th}$ to the 95$^{th}$ in 5-percentile intervals. In addition, Virginia Marchman provided norms in 1-percentile units for the 1$^{st}$ through 25$^{th}$ percentiles for both the CDI-WG and the CDI-WS based on the CDI norming sample (personal communication to Carolyn Mervis, January 11, 2016).

## Procedure

Parents completed the modified Vocabulary Checklist and the Early Communicative Checklist. For the Vocabulary Checklist, parents were instructed to mark with an S each word that their child understood and said spontaneously (not in imitation or as part of a song), to mark with an M (for "manual sign") each word that their child understood and signed spontaneously (not after someone else had said or signed the word or as part of a song), and to mark with a B (for "both") each word that their child understood, said, and signed spontaneously. If the child did not say or sign a word spontaneously but did understand the word, the parent was asked to mark the word with a U. A word was considered to be included in the child's EV if the parent marked the word "S," "M," or "B." A word was considered to be in the child's RV if the parent marked the word "U," "S," "M," or "B."

For the ECC, parents indicated if they had seen the child do the different gestures. For each item on the First Communicative Gestures section parents selected one of three choices (Never, Sometimes, Often) For the Games and Routines section parents indicated one of two choices (Not Yet, Yes). For the three remaining sections, parents put a checkmark next to each item if the child had produced the behavior on his or her own. A gesture was considered to be in the child's EG if the parent marked a First Communicative Gestures item "Sometimes" or "Often" or marked a Games and Routines item "Yes." A gesture was considered to be in the child's LG if the parent checked the item on the three remaining sections. The child's TG was the sum of his or her EG plus LG.

## Results

### Lexical Abilities: CDI-WG

In order to characterize RV and EV abilities for 18-month-old children with WS, nonparametric descriptive statistics were computed based on parental report for the 49 participants. The CDI-WG vocabulary items were extracted from the modified Vocabulary Checklist using a specially-written program. CDI-WG vocabulary sizes corresponding to various percentile rankings for the WS sample are presented in Table 3.

Table 3
*Descriptive Statistics for Receptive and Expressive Vocabulary Size: CDI-WG.*

| | Number of words | |
|---|---|---|
| | RV (CDI-WG) | EV (CDI-WG) |
| Minimum | 2 | 0 |
| 5th Percentile | 8 | 0 |
| 10th Percentile | 11 | 0 |
| 25th Percentile | 16 | 1 |
| 50th Percentile | 36 | 3 |
| 75th Percentile | 68 | 11 |
| 90th Percentile | 105 | 16 |
| 95th Percentile | 115 | 22 |
| Maximum | 129 | 31 |

In order to determine how lexical abilities of 18-month-olds with WS compare to same-aged TD children percentile ranks for each individual's RV, EV size, were determined based on the CDI-WG norms. Figures 1 and 2 show boxplots of the distribution of lexical abilities in 18-month-olds with WS as measured by the CDI-WG. The boxes in these plots present the median and inter-quartile ranges, the tails represent the top and bottom 25% of the scores (excluding outliers). Outliers are represented by individual markers.

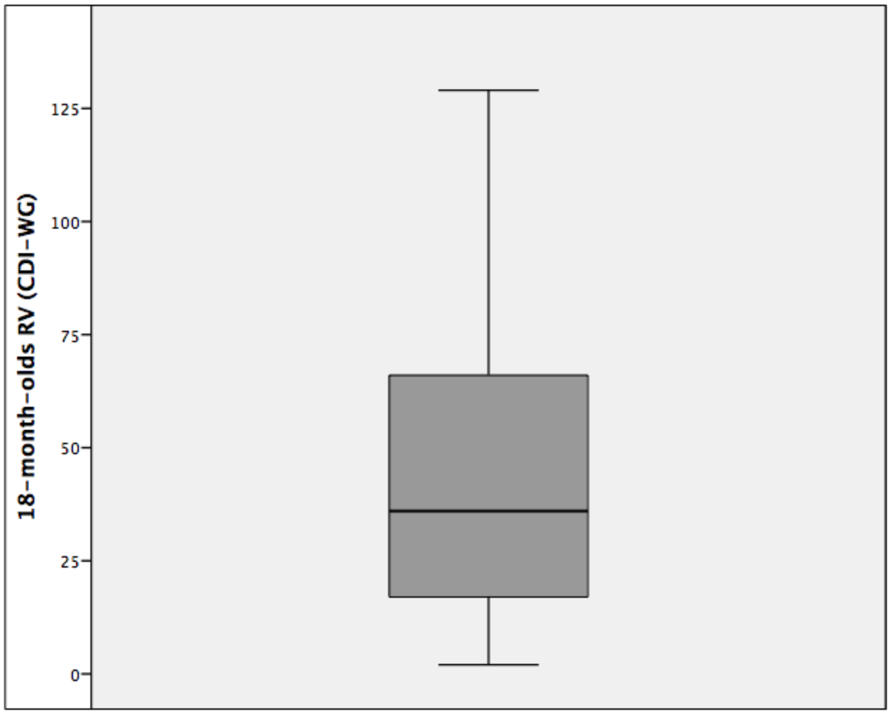


Figure 1. Boxplot of RV size from the CDI-WG for 18-month-old children with WS.

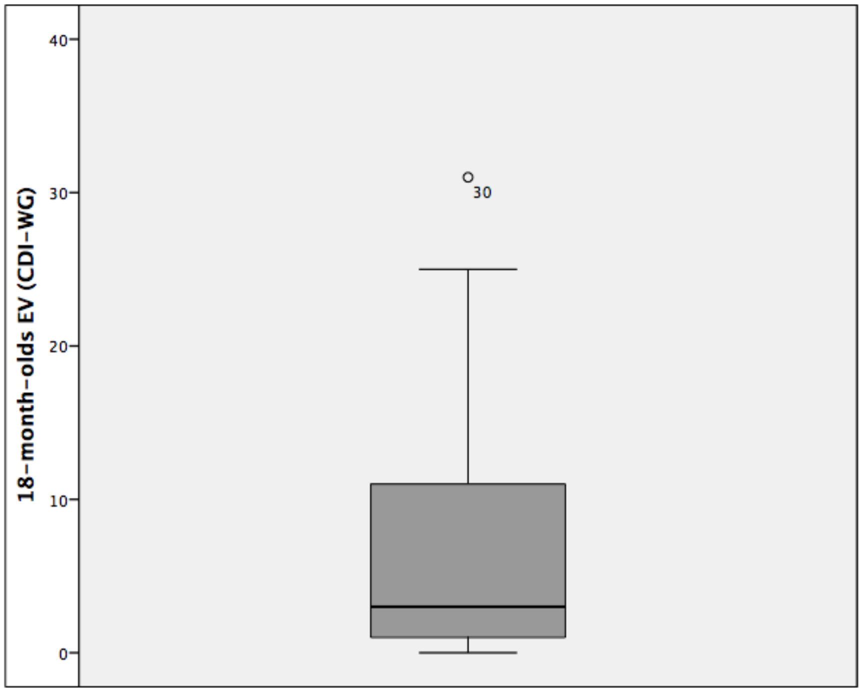

Figure 2. Boxplot of EV size from CDI-WG for 18-month-olds with WS.

All 49 children with WS had a RV size below the 10th percentile, when compared to the CDI norms. A total of 30 children scored below the 1st percentile, 15 children scored between the 1st and 5th percentile and 4 children between the 6th and 9th percentile. All 49 children scored below the 15th percentile for EV as measured by the CDI-WG, with 11 children at the 2nd percentile, 15 at the 5th percentile, 19 children between the 6th and 9th percentile, and 4 children between the 10th and 13th percentile.

**Gestural Abilities**

In order to characterize gestural abilities for 18-month-old children with WS nonparametric descriptive statistics for gestural abilities were determined from parental report on the CDI-WG. CDI-WG gestural abilities, corresponding to various percentile rankings for the WS sample are presented in Table 4.

Table 4

*Descriptive Statistics for Gestural Abilities: CDI-WG*

| | Number of gestures | | |
|---|---|---|---|
| | Early Gestures (out of 18) | Late Gestures (out of 45) | Total Gestures (out of 63) |
| Minimum | 1 | 1 | 3 |
| 5th Percentile | 2 | 2 | 6 |
| 10th Percentile | 3 | 4 | 9 |
| 25th Percentile | 5 | 8 | 14 |
| 50th Percentile | 9 | 11 | 18 |
| 75th Percentile | 11 | 15 | 25 |
| 90th Percentile | 13 | 20 | 33 |
| 95th Percentile | 14 | 23 | 36 |
| Maximum | 15 | 27 | 42 |

In order to determine how gestural abilities of 18-month-olds with WS compare to same-aged TD children percentile ranks for each individual's EG, LG, and TG, were determined based on the CDI-WG norms. Figures 3 to 5 show the distribution of gestural abilities in 18-month-old children with WS. The boxes in these plots present the median and inter-quartile ranges, the tails represent the top and bottom 25% of the scores. Outliers are represented by individual markers.

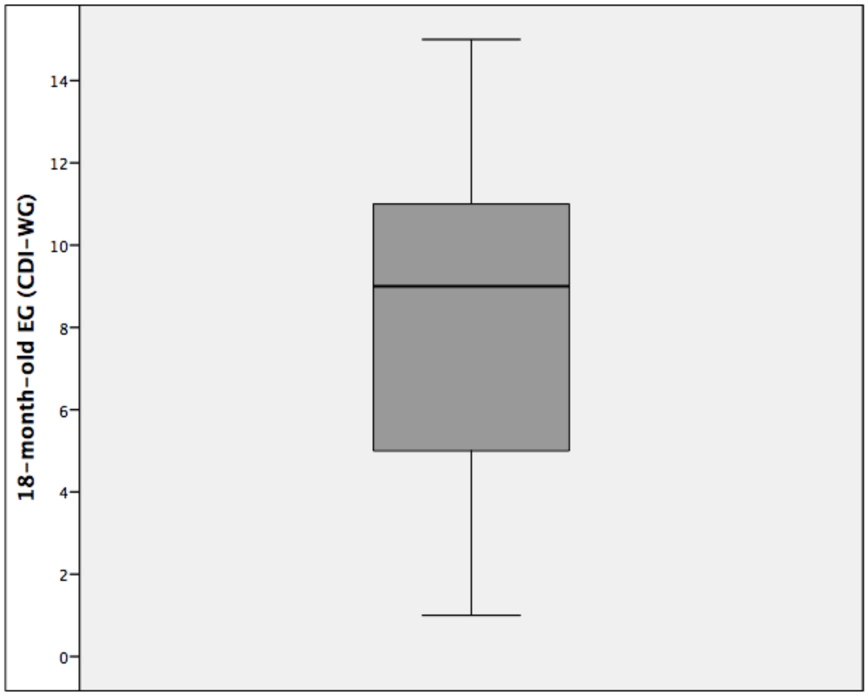


Figure 3. Boxplot of EG from the CDI-WG for 18-month-olds with WS.

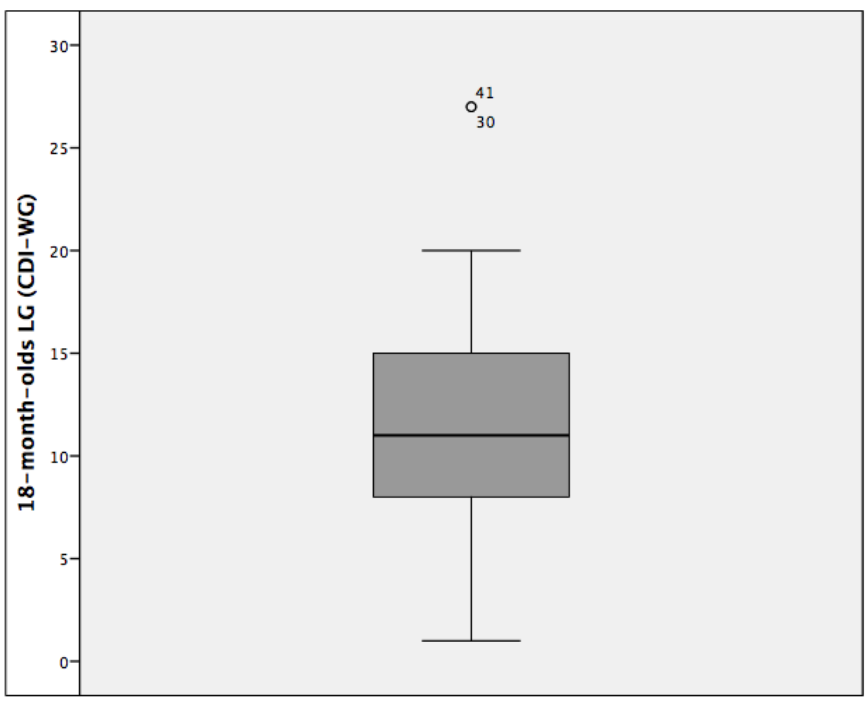


Figure 4. Boxplot of LG for 18-month-olds with WS.

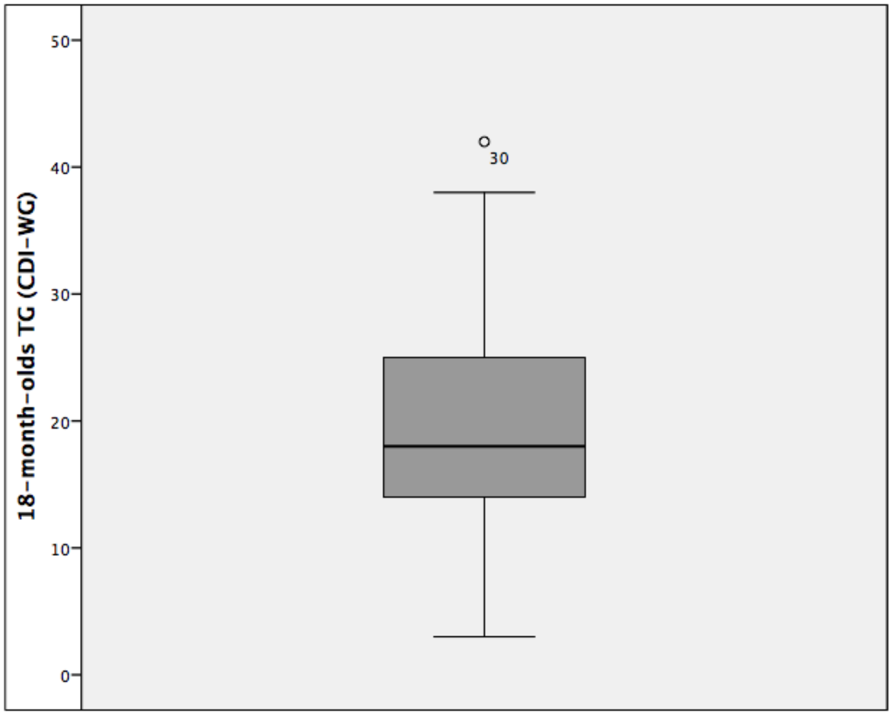

Figure 5. Boxplot of TG for 18-month-olds with WS.

Regarding gestural abilities, when compared to the norms for EG (CDI-WG) all but 3 participants scored below the 15th percentile, with 21 children below the 1st percentile, 20 children between the 1st and 5th percentile, 5 children at the 15th percentile. The remaining 3 children, 1 was at the 25th percentile, and 2 at the 45th percentile. With respect to LG, all children were at or below the 15th percentile, with 39 children with WS below the 1st percentile, 8 children between the 1st and 3rd percentile and 2 at the 15th percentile. All children with WS score below the 20th percentile, when compared to the norms for TG, with 37 children below the 1st percentile, 9 children between the 1st and 5th percentile, 2 between the 6th and 10th percentile, and 1 child at the 18th percentile.

**Lexical Abilities: CDI-WS**

In addition, lexical abilities were also determined from the CDI-WS. Descriptive statistics for RV and EV are presented in Table 5. Boxplots showing the distribution of RV and EV are presented in Figures 6 and 7.

Table 5

*Nonparametric Descriptive Statistics for Early Lexical Abilities: CDI-WS*

| | Number of words | |
|---|---|---|
| | Receptive Vocabulary (CDI-WS) | Expressive Vocabulary (CDI-WS) |
| Minimum | 3 | 0 |
| 5th Percentile | 9 | 0 |
| 10th Percentile | 13 | 0 |
| 25th Percentile | 18 | 1 |
| 50th Percentile | 41 | 3 |
| 75th Percentile | 78 | 11 |
| 90th Percentile | 121 | 17 |
| 95th Percentile | 134 | 22 |
| Maximum | 146 | 31 |

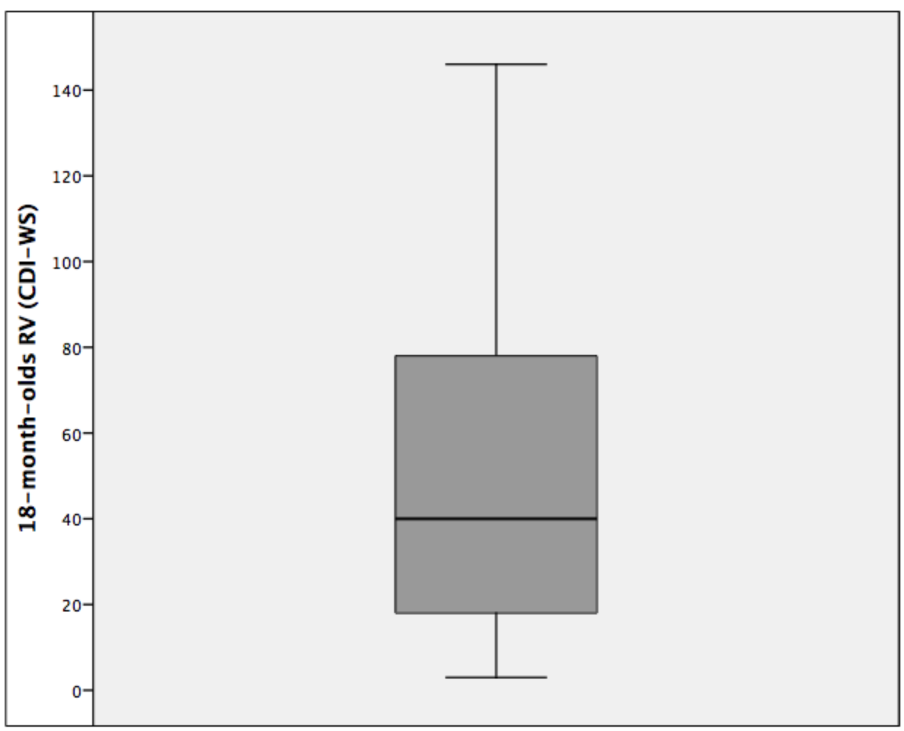

Figure 6. Boxplot of RV from the CDI-WS for 18-month-old children with WS.

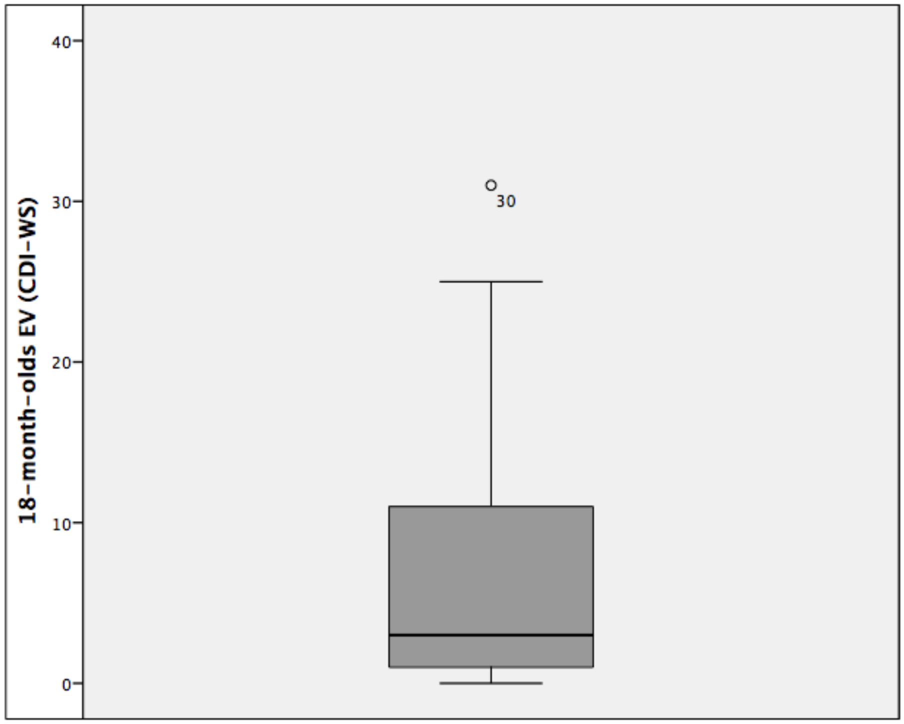


Figure 7. Boxplot of EV from the CDI-WS for 18-month-olds with WS

Further analysis to determine how EV abilities for 18-month-old children with WS, as measured by the CDI-WS, compared to the norms for TD children was performed. Percentile ranks for each individual were determined for EV from the CDI-WS norms. The CDI-WS does not provide norms for RV.

All children with WS scored under the $20^{th}$ percentile for EV as measured by the CDI-WS norms. Eighteen children scored below the $1^{st}$ percentile, 10 children at the $1^{st}$ percentile, 9 children between the $2^{nd}$ and $5^{th}$ percentile, 9 children between the $6^{th}$ and $10^{th}$ percentile, and 3 children between the $11^{th}$ and $19^{th}$ percentile.

## Discussion

In the present chapter, characteristics of early lexical and gestural development for 18-month-old children with WS were described. These results show great variability for both RV and EV abilities, as well as for gestural development. Lexical and gestural abilities in children with WS show a significant delay in development, when compared to TD children. The present results confirm previous findings of a significant delay in early lexical and gestural abilities for most children with WS (Mervis & Becerra, 2007; Mervis & Robinson, 2000; Singer-Harris et al., 2003).

The present study, provides a greater description of the delay in development and variability of lexical and gestural abilities of younger children with WS. With regard to RV abilities, the median RV (CDI-WG) was 36 words and ranged from 2 to 129 words. When RV was measured with the CDI-WS, the median was 41 words and ranged from 3 to 134 words. When compared to the norms for TD children for the CDI-WG, all 18-month-old children with WS are below the 20$^{th}$ percentile for RV abilities.

EV abilities were very similar in the present study when measured by either the CDI-WG and CDI-WS, with both medians for EV of 3 words and a range from 0 words to 22 words. When compared to the norms for TD children, all children with WS showed EV abilities below the 15$^{th}$ percentile for the CDI-WG. In the present study, when EV from the CDI-WS was compared to the norms for TD children, all children scored below the 20$^{th}$ percentile, with 37 children below the 5$^{th}$ percentile, 9 children between the 6$^{th}$ and 10$^{th}$ percentile and 3 children between the 11$^{th}$ and 19$^{th}$ percentile. These results evidence the significant delay for both RV and EV abilities in very young children with WS.

The findings in this study provide a characterization of lexical and gestural abilities in 18-month-old children with WS. Additional analysis is needed to determine how these abilities further relate to each other during early development for young children with

WS. Study 2, will describe lexical and gestural abilities from the CDI-WS in 18-, 24- and 30-month-olds with WS. Then, concurrent correlations between lexical and gestural abilities at 18-, 24- and 30- months of age will be analyzed.

To study the extent of the relation among components from the CDI-WG, dissociation norms are available (Bates, unpublished; Virginia Marchman, personal communication to Carolyn Mervis, January 11th, 2016). These dissociation norms will be used in the next chapter to further determine the extent of the relation among lexical and gestural abilities in children with WS.

# CHAPTER III

# RELATIONS BETWEEN CONCURRENT GESTURAL AND LEXICAL ABILITIES DURING EARLY DEVELOPMENT IN CHILDREN WITH WS

The aim of Study 2 was to determine the relations among lexical and gestural abilities in early development in children with WS. This study was divided into three different analyses. The first part of this study describes the characteristics of early gestural and lexical abilities of 18-, 24-, and 30-month-olds with WS. The goal for the second analysis was to determine the intercorrelations among lexical and gestural abilities at 18-, 24- and 30-months of age for participants with WS. In the final part of this study, I analyzed the relations between components of the CDI-WG based on the dissociation norms for TD children (Virginia Marchman, 2016).

## Method

### Participants

The children who participated in the present study are also part of the study on early language and cognitive development of children with neurodevelopmental disorders conducted by Dr. Carolyn B. Mervis at the Neurodevelopmental Sciences Laboratories at the University of Louisville.

The group of 18-month-olds included 49 children (25 boys, 24 girls) aged 18.00 – 18.96 months (*M* = 18.50; SD = .30). This group of children is the same group as was included in Chapter II. The group of 24-month-olds included 56 children (30 boys, 26 girls) aged 24.02 – 24.97 months (*M* = 24.50; *SD* = .29). The 30-month-old group included 55 children (27 boys, 28 girls) aged 30.03 – 30.95 months (*M* = 30.60; *SD* = .27).

**Measure**

**MacArthur-Bates Communicative Development Inventories (CDI; Fenson et. al., 1993, 2007)**

Lexical and gestural abilities were determined from parental report on the CDI-WG and CDI-WS (described in Chapter II). For the first two parts of this study, EV and RV were determined based on parental report on the CDI-WS.

Normative data for dissociations between various dimensions of language and communicative development assessed by the CDI-WG are available (Bates, unpublished; Virginia Marchman, personal communication to Carolyn Mervis, January 11, 2016). These norms provide information on the variability of development on one dimension measured by the CDI in the context of another. Norms are available for EG, LG, TG, and EV in the context of RV, as well as for EG, LG, and TG in the context of EV. The norms for these dissociations are presented in the form of what Bates referred to as "dissociation percentiles". To determine possible dissociations between EV and RV, RV size was divided into eight intervals: 0-20, 21-50, 51-100, 101-150, 151-200, 201-250, 251-300, and >301 words. Each child was ranked in a specific percentile based on his or her EV size within the RV interval corresponding to his or her RV size. The same procedure was followed to determine dissociation percentiles for EG, LG, and TG within the context of RV. To determine possible dissociations for EV, EV size was divided into six intervals:

1-5, 6-10, 11-20, 21-50, 51-100 and >100 words. To determine dissociations between EV and TG from the CDI-WG each child was ranked in a specific percentile based on the number of TG produced within a specific EV interval. Additional dissociation percentiles can be determined for EG and LG in the context of the same EV intervals.

### Procedure

Parents filled out the CDI-WG and CDI-WS as described in Chapter II.

## Results

### Descriptive Statistics for Lexical and Gestural Abilities

The lexical abilities, as measured by the CDI-WS, of 18-, 24-, and 30-month-old children with WS are described in Table 6. Gestural abilities as measured by the CDI-WG for 18-. 24-, and 30-month-old children with WS are presented in Table 7.

Table 6

*Descriptive Statistics for CDI-WS Receptive Vocabulary and Expressive Vocabulary for 18-, 24- and 30-month-olds.*

| | RV (number of words) | | | | EV (number of words) | | | |
|---|---|---|---|---|---|---|---|---|
| Age | *M* | *SD* | *Mdn* | Range | *M* | *SD* | *Mdn* | Range |
| 18 months | 51.57 | 38.5 | 40.0 | 3 – 146 | 6.20 (7.15) | 7.15 | 3.0 | 0 – 31 |
| 24 months | 125.20 | 78.4 | 131 | 3 – 308 | 34.71 | 38.36 | 21.0 | 0 – 176 |
| 30 months | 238.37 | 142.0 | 230 | 6 – 524 | 114.24 | 108.37 | 75.0 | 0 – 435 |

Table 7

*Descriptive Statistics for CDI-WG Early Gestures, Late Gestures and Total Gestures for 18-, 24- and 30-month-olds*

| | EG (out of 18) | | | | LG (out of 45) | | | | TG (out of 63) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | *M* | *SD* | *Mdn* | Range | *M* | *SD* | *Mdn* | Range | *M (SD)* | *SD* | *Mdn* | Range |
| 18 months | 8.49 | 3.70 | 9.0 | 1 – 15 | 11.86 | 5.85 | 11.0 | 1 – 27 | 20.37 | 8.81 | 18.0 | 3 – 42 |
| 24 months | 12.45 | 4.36 | 13.0 | 2 – 18 | 19.79 | 8.76 | 20.5 | 2 – 41 | 32.25 | 12.33 | 32.5 | 5 – 59 |
| 30 months | 13.84 | 4.26 | 15.0 | 3 - 18 | 28.04 | 10.36 | 28.0 | 5 – 42 | 41.91 | 13.98 | 43.0 | 8 - 60 |

In order to determine how lexical abilities of 24-month-olds with WS compare to same-aged children in the general population, percentile ranks for each individual's EV size were determined based on the CDI-WS norms. More than three-fourths of the children scored at or below the $5^{th}$ percentile. A total of 15 children scored below the $1^{st}$ percentile, 12 children scored at the $1^{st}$ percentile and 17 children between the $2^{nd}$ and $5^{th}$ percentile. Of the remaining children, 4 scored between the $6^{th}$ and $9^{th}$ percentile, 5 between the $10^{th}$ and $15^{th}$ percentile, 2 between the $16^{th}$ and $20^{th}$ percentile, and 1 at the $25^{th}$ percentile.

Percentile ranks for each individual's EV size at 30 months also were determined based on the norms for the CDI-WS. Once again, about three-fourths of the children scored at or below the $5^{th}$ percentile for the CDI-WS norms. A total of 21 children scored below the $1^{st}$ percentile, 6 children scored at the $1^{st}$ percentile and 14 children scored between the $2^{nd}$ and $5^{th}$ percentile. Of the remaining children, 6 scored between the $6^{th}$ and $10^{th}$ percentile, 7 between the $10^{th}$ and $15^{th}$ percentile, and 1 at the $25^{th}$ percentile.

**Concurrent Correlations among Lexical and Gestural Abilities**

The study in Chapter II presented evidence for the degree of delay of lexical and gestural abilities in children with WS. Studies of TD children and children with DD have shown a significant correlation between concurrent lexical and gestural abilities (Caselli & Casadio, 1995; Zampini & D'Odorico, 2011). The purpose of the present analysis was to determine if similar correlations between lexical and gestural abilities are also evidenced by children with WS.

Normality of the distribution by the variables was not met by EV, and RV at 18-, 24-, and 30-months of age. Therefore, Spearman correlations were computed among lexical and gestural abilities, separately for 18-month-olds, 24-month-olds, and 30-month-olds. Spearman's correlations among EG, LG, EV, and RV for each age group were determined. An additional set of correlations was computed for TG, EV, and RV. EV and RV were determined based on the CDI-WS. Strong and significant correlations were found among all components of lexical and gestural abilities for all three age groups. Results for these correlations are presented in Tables 8, 9 and 10.

Table 8

*Spearman Correlations between RV, EV, EG, LG and TG for 18-month-olds*

| | CDI-WS RV | CDI-WS EV | CDI-WG EG |
|---|---|---|---|
| CDI-WS EV | .652** | | |
| CDI-WG EG | .733** | .670** | |
| CDI-WG LG | .590** | .503** | .679** |
| CDI-WG TG | .718** | .645** | |

**p<.01

Table 9

*Spearman Correlations between RV, EV, EG, LG, and TG for 24-month-olds*

| | CDI-WS RV | CDI-WS EV | CDI-WG EG |
|---|---|---|---|
| CDI-WS EV | .739** | | |
| CDI-WG EG | .677** | .722** | |
| CDI-WG LG | .797** | .821** | .702** |
| CDI-WG TG | .812** | .854** | |

**p<.01

Table 10

*Spearman Correlations between RV, EV, EG, LG, and TG for 30-month-olds.*

| | CDI-WS RV | CDI-WS EV | CDI-WG EG |
|---|---|---|---|
| CDI-WS EV | .865** | | |
| CDI-WG EG | .747** | .687** | |
| CDI-WG LG | .861** | .832** | .755** |
| CDI-WG TG | .872** | .828** | |

**p<.01

These results show that lexical abilities (RV and EV) significantly correlate with each other and with gestural abilities (EG, LG, and TG) in children with WS at 18-, 24-, and 30- months of age.

**Dissociations between Lexical and Gestural Abilities**

Further analyses to characterize the relations among components of lexical and gestural abilities relative to the corresponding relations for children in the CDI norming sample were performed using the CDI dissociation norms (Bates, unpublished; Virginia Marchman, personal communication to Carolyn Mervis, January 11, 2016). Dissociation analyses were first performed for EV, EG, LG, and TG as a function of RV abilities. In addition, dissociation analyses were conducted for EG, LG, and TG as a function of EV abilities.

Dissociation percentile rankings between EV and RV when children's RV was between 21-50 total words, 51-100 words, 101-150 words, 151- 200 words, 201-250 words, and 251-300 words were determined. For longitudinal participants for whom more than one data point was available for a given RV interval, the EV at the time the child's RV was closest to the median of the RV interval (35, 75, 125, 175, 235, and 275 words respectively) was used in the analysis. Table 11 shows the characteristics of the sample for each of the RV intervals.

Table 11

*Descriptive Characteristics of the Children in Each of the RV Intervals.*

| | | Age in months | |
|---|---|---|---|
| RV interval | *N* | *M* (SD) | *Range* |
| 21-50 words | 52 | 20.62 (4.67) | 13.41 – 31.93 |
| 51-100 words | 56 | 23.96 (6.38) | 14.92 – 48.46 |
| 101-150 words | 56 | 27.60 (6.60) | 18.33 – 45.17 |
| 151-200 words | 52 | 30.45 (7.54) | 20.20 – 48.72 |
| 201-250 words | 45 | 32.97 (7.28) | 21.82 – 48.72 |
| 251-300 words | 39 | 34.94 (7.22) | 23.95 – 48.85 |

Results for the dissociations between EV and RV are presented in Table 12. These results show the number and percentage of children who are at or below the 45$^{th}$ percentile and the percentage and number who were at or above the 50$^{th}$ percentile for the CDI norms for each of the individual RV intervals. In addition, the table includes the median percentile and range for each of the intervals. Chi-squares were computed to determine if there was a significant difference in the proportion of children below vs. at or above the median for the children in the CDI norming sample.

Table 12

*Distribution of Percentile Ranks for EV for Each RV Interval*

| | | $0 – 49^{th}$ percentile | | $50 – 99^{th}$ percentile | | *Mdn* percentile | Range | $\chi^2$ | *p* |
|---|---|---|---|---|---|---|---|---|---|
| RV interval | *N* | N | % | N | % | | | | |
| 21-50 | 52 | 21 | 40.4 | 31 | 59.6 | 65.0 | 25 - 95 | 1.92 | .166 |
| 51-100 | 56 | 14 | 25.0 | 42 | 75.0 | 67.5 | 20 – 95 | 14.00 | <.0001 |
| 101-150 | 56 | 14 | 25.0 | 42 | 75.0 | 80.0 | 20 - 95 | 14.00 | <.0001 |
| 151-200 | 52 | 9 | 17.3 | 43 | 82.7 | 85.0 | 20 – 95 | 22.23 | <.0001 |
| 201-250 | 45 | 5 | 11.1 | 40 | 88.9 | 90.0 | 20 – 95 | 27.22 | <.0001 |
| 251-300 | 39 | 2 | 5.1 | 37 | 94.9 | 85.0 | 25 - 95 | 31.41 | <.0001 |

The results in Table 12 show that significantly more children than expected scored at or above the $50^{th}$ percentile when their EV size was analyzed within a given RV, when compared to the general population. This difference does not show for children who have and RV size below 50 words.

To determine the relation between gestures and receptive vocabulary, dissociation percentile rankings for EG, LG, and TG, when RV was between 21-50, 51-10, 101-150, 151-200, 201-250, and 251-300 words were determined. As in the previous analysis, for longitudinal children for whom more than one data point was available within a single RV interval, the data point from the session in which the child's RV was closest to the median of the interval was used. Tables 13, 14 and 15 show split half distributions, median percentile, and Chi-square results for each interval for EG, LG, and TG respectively.

Table 13

*Distribution of Percentile Ranks for EG for Each RV Interval*

| | | 0 – 49th percentile | | 50 – 99th percentile | | *Mdn* percentile | Range | $\chi^2$ | *p* |
|---|---|---|---|---|---|---|---|---|---|
| RV interval | *N* | N | % | N | % | | | | |
| 21-50 | 52 | 34 | 65.4 | 18 | 34.6 | 45.0 | 0 - 95 | 1.53 | .216 |
| 51-100 | 56 | 17 | 30.4 | 39 | 69.6 | 57.5 | 1 – 95 | 14.00 | <.0001 |
| 101-150 | 56 | 16 | 28.6 | 40 | 71.4 | 75.0 | 1 – 95 | 14.00 | <.0001 |
| 151-200 | 52 | 18 | 34.6 | 34 | 65.4 | 75.0 | <1 – 95 | 22.23 | <.0001 |
| 201-250 | 45 | 5 | 11.1 | 40 | 88.9 | 65.0 | 1 – 95 | 27.22 | <.0001 |
| 251-300 | 39 | 14 | 35.9 | 25 | 64.1 | 70.0 | 5 - 95 | 31.41 | <.0001 |

The results in Table 13 show that significantly more children than expected scored at or above the 50th percentile when EG abilities were analyzed within a given RV, when compared to the general population. This difference is not true for children with a RV below 50 words.

Table 14

*Distribution of Percentile Ranks for LG for Each RV Interval*

| | | 0 – 49th percentile | | 50 – 99th percentile | | *Mdn* percentile | Range | $\chi^2$ | *p* |
|---|---|---|---|---|---|---|---|---|---|
| RV interval | *N* | N | % | N | % | | | | |
| 21-50 | 52 | 14 | 26.9 | 38 | 73.1 | 65.0 | 5 - 95 | 11.07 | <.001 |
| 51-100 | 56 | 13 | 23.2 | 43 | 76.8 | 65.0 | 20 – 95 | 16.07 | <.0001 |
| 101-150 | 56 | 16 | 28.6 | 40 | 71.4 | 70.0 | 20 - 95 | 10.28 | <.001 |
| 151-200 | 52 | 21 | 40.4 | 31 | 59.6 | 72.5 | 20 – 95 | 1.92 | .166 |
| 201-250 | 45 | 11 | 24.4 | 34 | 75.6 | 60.0 | 20 – 95 | 11.75 | <.001 |
| 251-300 | 39 | 8 | 20.5 | 31 | 79.5 | 75.0 | 25 - 95 | 13.56 | <.0001 |

The results in Table 14 show that significantly more children than expected scored at or above the $50^{th}$ percentile when LG abilities were analyzed within a given RV size, when compared to the general population. No significant difference was found in the distribution between the split half when RV size was between 151 – 200 words.

Table 15

*Distribution of Percentile Ranks for TG for Each RV Interval*

| | | 0 – 49th percentile | | 50 – 99th percentile | | *Mdn* percentile | Range | $\chi^2$ | *p* |
|---|---|---|---|---|---|---|---|---|---|
| RV interval | *N* | N | % | N | % | | | | |
| 21-50 | 52 | 17 | 32.7 | 35 | 67.3 | 60.0 | 1 - 95 | 6.21 | <.013 |
| 51-100 | 56 | 19 | 33.9 | 37 | 66.1 | 65.0 | 10 – 95 | 5. 78 | <.016 |
| 101-150 | 56 | 15 | 26.8 | 41 | 73.2 | 70.0 | 5 - 95 | 12.07 | <.001 |
| 151-200 | 52 | 20 | 38.5 | 32 | 61.5 | 60.0 | 1 – 95 | 2.77 | .096 |
| 201-250 | 45 | 13 | 28.9 | 32 | 71.1 | 80.0 | 10 – 95 | 8.02 | <.005 |
| 251-300 | 39 | 9 | 23.1 | 30 | 76.9 | 85.0 | 1 - 95 | 11.31 | <.001 |

The results in Table 15 show that significantly more children than expected scored at or above the $50^{th}$ percentile when EG abilities were analyzed within a given RV, when compared to the general population. This difference is not true for children with a RV between 151 – 200 words.

The final analysis examined the relation between gestures and EV. Dissociation percentiles between EG, LG and TG, when children's EV is between 6-10, 11-20, 21-50, and 51-100 words were determined. For children with multiple data points within a single EV interval, the data from the session in which the child's EV was closest to the median of the interval (8, 15, 35, and 75 words) was used.  Table 16 describes characteristics of the children in each of the EV intervals.

Table 16

*Descriptive Characteristics of the Children in Each of the EV Intervals*

| | | Age in months | |
|---|---|---|---|
| EV interval | *N* | *M* (SD) | *Range* |
| 6-10 words | 51 | 23.24 (6.37) | 15.90 – 43.79 |
| 11-20 words | 51 | 25.75 (7.80) | 16.95 – 48.46 |
| 21-50 words | 56 | 29.08 (8.16) | 19.45 – 48.82 |
| 51-100 words | 50 | 30.44 (6.74) | 20.83 – 48.43 |

Tables 17, 18 and 19 show the proportion of children in each split half based on EG, LG, and TG for each of the EV intervals. Chi-square results are also shown for each of the gestural abilities.

Table 17

*Distribution of Percentile Ranks for EG for Each EV Intervals*

| | | 0 – 49th percentile | | 50 – 99th percentile | | *Mdn* percentile | Range | $\chi^2$ | *p* |
|---|---|---|---|---|---|---|---|---|---|
| EV interval | *N* | N | % | N | % | | | | |
| 6-10 | 51 | 32 | 62.7 | 19 | 37.3 | 40.0 | 0 - 95 | 3.31 | .069 |
| 11-20 | 51 | 28 | 54.9 | 23 | 45.1 | 40.0 | 0 – 95 | 0.49 | .484 |
| 21-50 | 56 | 18 | 32.1 | 38 | 67.9 | 65.0 | 1 - 95 | 7.14 | <.008 |
| 51-100 | 50 | 16 | 32.0 | 34 | 68.0 | 57.5 | 0 – 95 | 6.48 | <.011 |

The results in Table 17 show that significantly more children than expected scored at or above the $50^{th}$ percentile when EG abilities were analyzed within a given EV, when EV size was above 20. The distribution of children in both half split does not show significant differences for EV sizes below 20 words.

Table 18

*Distribution of Percentile Ranks for LG for Each EV Intervals*

| | | $0 – 49^{th}$ percentile | | $50 – 99^{th}$ percentile | | *Mdn* percentile | Range | $\chi^2$ | *p* |
|---|---|---|---|---|---|---|---|---|---|
| EV interval | *N* | N | % | N | % | | | | |
| 6-10 | 51 | 27 | 52.9 | 24 | 47.1 | 40.0 | 0 - 95 | 0.176 | =.674 |
| 11-20 | 51 | 28 | 54.9 | 23 | 45.1 | 40.0 | 0 – 90 | 0.49 | =.484 |
| 21-50 | 56 | 27 | 48.2 | 29 | 51.8 | 50.0 | 0 - 95 | 0.71 | =.789 |
| 51-100 | 50 | 28 | 56.0 | 22 | 44.0 | 35.0 | 0 – 95 | 0.72 | =.396 |

Table 18 show no significant difference in the distribution between the split half for percentile ranks on LG abilities within EV size intervals, when compared to children in the general population.

Table 19

*Distribution of the Percentile Ranks for TG for Each EV interval.*

| | | $0 – 49^{th}$ percentile | | $50 – 99^{th}$ percentile | | *Mdn* percentile | Range | $\chi^2$ | *p* |
|---|---|---|---|---|---|---|---|---|---|
| EV interval | *N* | N | % | N | % | | | | |
| 6-10 | 51 | 29 | 56.9 | 22 | 43.1 | 35.0 | 0 - 95 | 0.96 | =.327 |
| 11-20 | 51 | 34 | 66.7 | 17 | 27.4 | 33.3 | 0 – 95 | 5.67 | =.017 |
| 21-50 | 56 | 28 | 50.0 | 28 | 67.9 | 50.0 | 0 - 90 | 0.00 | =1.00 |
| 51-100 | 50 | 27 | 54.0 | 23 | 46.0 | 35.0 | 0 – 90 | 0.32 | =.572 |

Table 19 show no significant difference in the distribution in the split half for the percentile ranks on LG abilities within EV size intervals, when compared to children in the general population.

No significant differences in the distribution of percentile ranks for TG abilities within the context of EV size for children with WS was found. Overall children with WS tend to have the same number of TG considering the level of EV abilities as TD children.

## Discussion

In the present study, two sets of analysis addressed the question of how do lexical and gestural abilities relate to each other in children with WS. The first analysis focused in concurrent correlations among lexical and gestural abilities at 18-, 24-, and 30-months of age. The second analysis, focused on the possible dissociations between lexical and gestural abilities in children with WS, based on the dissociation norms.

To date, studies on the correlations among lexical and gestural abilities in TD children have been consistent in showing significant correlations among these abilities early in development. The literature in children with DD has presented conflicting evidence for these relations in part due by the smaller sample sizes of the studies or by inconsistency in the research tools used to determine lexical and gestural abilities.

The present cross-sectional study, presents a large sample of children with WS at 18-, 24- and 30- months of age. The methods used in this study are consistent to the ones used in most studies with TD children. Findings in the present study confirm strong correlation among lexical and gestural abilities for children with WS at all three age groups, similar to the results found in TD children. These results contribute to the theory that gestural and lexical abilities are linked early in development.

Dissociation norms from the CDI-WG were used to analyze the relation between EV, EG, LG, and TG as a function of RV abilities. These results show that significantly more children scored at or above the 50% percentile when EV, EG were analyzed as a function of RV size, when RV size was below 50 words. When LG were considered as a function of RV, significantly more children than expected were at or above the $50^{th}$ percentile for all RV size intervals, with the exception of RV interval between 151 – 200 words. When the median is analyzed for this interval (median percentile of 72.5) results suggest that with a higher sample the difference would be significant for this interval or not be significant at all for all the other intervals, (median percentile for RV size below 100 words was 65, between 101 – 150 words median was 70, between 201 -250 median percentile rank was 65, and between 251 – 300 median percentile rank was 75).

When EG, LG, and TG were analyzed as a function of EV size, significantly more children than expected scored at or above the $50^{th}$ percentile when EV size was above 20 words. No significant differences were found for LG or TG as a function of EV size.

The present study shows that concurrent relations between gestures and lexical abilities are significant in children with WS. Further analysis needs to be done on the longitudinal relations between gestures and lexical abilities in children with WS. In Chapter IV, I will analyze the longitudinal correlations between gestural and lexical abilities in children with WS. In addition, I will study the correlations between age of onset of deictic gestures and lexical abilities at 48 months of age in children with WS. Finally, I will analyze the predictive value of early lexical abilities to later vocabulary and intellectual abilities in children with WS.

# CHAPTER IV

# RELATIONS OF GESTURES AND EARLY LEXICAL ABILIITES TO LATER LANGUAGE AND INTELLECTUAL ABILITIES IN CHILDREN WITH WS

The aim of Study 3 was to examine how early gestural and lexical development relate to later language and intellectual abilities in children with WS. In order to address this question three different sets of analyses were performed. The first set of analyses considered the relation of gestural and lexical abilities at 18 months of age to gestural and lexical abilities at 30 months of age. The second set focused on the relation between age of acquisition of deictic gestures and expressive vocabulary size at 48 months of age. The final series of analyses addressed the question of whether deictic gestural abilities and expressive vocabulary size at 24 months of age predicted language and intellectual abilities at 4 years of age.

## General Method

### Participants

All participants in the studies in this chapter are part of an ongoing longitudinal study of early language and intellectual abilities in children with WS, conducted by Dr. Carolyn B. Mervis at the Neurodevelopmental Sciences Laboratory at the University of Louisville.

Participants in each set of analysis will be described separately for each section in the present study.

## Procedure

Parents filled out the CDI as described in Chapters II and III.

## Relations of Gestural and Lexical Abilities at 18 Months of Age to Gestural and Lexical Abilities at 30 Months of Age

The first analysis examined relations of gestural and lexical abilities at 18 months of age to gestural and lexical abilities at 30 months in children with WS. Correlations were calculated between RV and EV from the CDI-WS and EG and LG from the CDI-WG at 18 months of age with the same measures at 30 months of age.

## Method

*Participants*. A total of 29 children (14 boys,15 girls) from the study described in Chapter II participated at both ages 18 and 30 months. Mean age at 18 months was 18.49 months (SD = .30, range: 18.00 and 18.94 months). At 30 months of age mean age was 30.60 (SD = .24, range: 30.03 – 30.95 months).

*Measure.* Lexical and gestural abilities determined from parental report at children's 18 and 30 months of age. EV and RV were determined from the CDI-WS. Gestural abilities in the present study were determined from the CDI-WG.

## Results

Descriptive statistics for RV and EV size at both 18 and 30 months are presented in Table 20. Descriptive statistics for gestural abilities at 18 and 30 months are presented in Table 21.

Table 20

*Descriptive Statistics for Receptive and Expressive Vocabulary Size: CDI-WS*

| | RV (# of words) | | | | EV (# of words) | | | |
|---|---|---|---|---|---|---|---|---|
| Age | *M* | *SD* | *Mdn* | Range | *M* | *SD* | *Mdn* | Range |
| 18 months | 60.76 | 37.90 | 57 | 13 - 146 | 7.79 | 8.22 | 4 | 0 - 31 |
| 30 months | 286.55 | 134.87 | 288 | 40 – 524 | 142.62 | 113.49 | 120 | 3 - 435 |

Table 21

*Descriptive Statistics for Gestural Abilities at 18- and 30-months: CDI-WG*

| | EG (out of 18) | | | | LG (out of 45) | | | | TG (out of 63) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | *M* | *SD* | *Mdn* | Range | *M* | *SD* | *Mdn* | Range | *M* | *SD* | *Mdn* | Range |
| 18 months | 9.21 | 3.77 | 11 | 1 – 15 | 13.59 | 5.69 | 12 | 4 – 27 | 22.83 | 8.69 | 23.00 | 10 - 42 |
| 30 months | 15.28 | 16.00 | 3.25 | 7 - 18 | 31.10 | 8.65 | 33.00 | 14 - 42 | 46.38 | 11.22 | 49.00 | 21 - 60 |

Histograms were created for EV, RV, EG, and LG to test for normality of the distributions. None of the variables had a normal distribution. Therefore, Spearman correlations were computed among measures of EV, RV, EG, and LG at 18 and 30 months of age. Results from these correlations are presented in Table 22.

Table 22

*Spearman Correlations of RV, EV, EG and LG at 18 Months of Age with RV, EV, EG, and LG at 30 Months*

| | | Lexical and gestural abilities at 30 months | | | |
|---|---|---|---|---|---|
| | | RV | EV | EG | LG |
| Abilities at 18 months | RV | .769** | .543** | .451* | .649** |
| | EV | .712** | .749** | .525** | .680** |
| | EG | .709** | .546** | .748** | .730** |
| | LG | .677** | .689** | .523** | .742** |

*$p$<.05, **$p$<.001

These results show significant and strong correlations among all measures of lexical and gestural abilities at 18 months of age with lexical and gestural abilities at 30 months of age.

**Relation Between Deictic Gestures and Lexical Abilities at 48 Months**

Previous studies that have analyzed the relation between gestural and lexical abilities in TD children have determined that onset of pointing gestures emerges prior to the onset of EV (Bates, 1976). These results are true not only for TD children (Adamson, 1995) but also for children with DS or severe developmental delay of mixed etiology (Mervis & Bertrand, 1997). More importantly, the onset of deictic gestures are semantically related the onset of spoken words in TD children (Iverson & Goldin-

Meadow, 2005). However, Mervis and Bertrand (1997) showed that in a sample of 10 children with WS the onset of referential pointing preceded the onset of referential language for only one child. To further explore the relation between onset of pointing and other deictic gestures (give and show) and the onset of expressive language, the present series of analyses will determine the age of onset for deictic gestures in children with WS and EV size at time of achievement of pointing. In addition, I will analyze the relation between age of onset of deictic gestures and lexical abilities at 48 months of age in children with WS.

**Method**

*Participants.* Age of acquisition of deictic gestures was available for 39 48-month-old children with WS (18 boys, 21 girls). Mean age at 48 months was 48.42 months (SD = .41, range: 47.5 – 48.97), with a median of 48.49 months.

*Measure*. Gestural abilities were determined from parental report on the CDI-WG. Lexical abilities were determined from parental report from the CDI-WS Vocabulary Checklist described in Chapter II.

**Procedure**

As part of an ongoing longitudinal study of early development in children with WS, parents filled out the checklists from the CDI on a monthly basis either by phone communication or by visiting the Neurodevelopmental Sciences Laboratory at the University of Louisville. Parents filled out the checklists as described in Chapter II.

**Data Analysis**

Age of onset of deictic gestures was determined from parental report on the CDI-WG based on the date on which parents first responded either “sometimes” or “often” to the following items from the First Communicative Gestures section of the CDI-WG: 1) Child extends arm to show you something he/she is holding, 2) Child reaches out and gives you a toy or some object that he/she is holding, and 3) Child points (with arm and index finger extended) at some interesting object or event. Some of the children in our sample at 48 months of age had not yet achieved some of the deictic gestures. For analytic purposes these children were given an age of 49 months as age of onset of that gesture.

**Results**

Of the 39 children who were included in this study, 34 had an age of onset of pointing of 48 months or younger. For those 34 children, mean age at the onset of pointing was 25.25 months (SD = 8.08, range: 14.55 – 44.55 months), with a median age of 23.50 months. Thirty-seven children had an onset of showing at 48 months or younger. For those 37 children mean age of onset of showing was 21.47 months, (SD = 5.29, range: 13.73 – 37.45 months); median age was 20.86 months. All 39 children started giving before 49 months of age. Mean age at onset of giving was 20.49 months (SD = 4.90, range: 13.37 – 34.04 months); median age was 19.25 months.

EV abilities, from the CDI-WS, were determined at the onset of each of the three deictic gestures for all children. Of the participants in this study, only one child had an onset of pointing before he produced any words spontaneously (EV size = 0 words); 5 children had an onset of showing before they produced any spontaneous words, and 7 children started giving when they had an EV of 0 words. Descriptive characteristics of EV size at onset of give, show, and point are shown in Table 23. This table includes EV size at 48 months for the 5 children who were not pointing by 48 months and for the 2 children who were not showing by 48 months.

Table 23

*EV Size at Age of Onset of Deictic Gestures in Children with WS*

| | | EV Size (# of words) | | | |
|---|---|---|---|---|---|
| | | *M* | *SD* | *Mdn* | Range |
| Deictic Gestures | Onset of give | 6.21 | 6.85 | 3 | 0 – 31 |
| | Onset of show | 11.59 | 16.24 | 7 | 0 – 88 |
| | Onset of point | 48.49 | 65.08 | 17 | 0 – 245 |

Variables of EV, age of onset of give, point and show failed the test of normality of the distribution, therefore Spearman correlations were used. Spearman correlations were computed between age at onset of pointing, age at onset of giving, age at onset of showing, and EV at 48 months of age. Results for these correlations are presented in Table 24.

Table 24

*Correlations Between Age of Onset of Deictic Gestures and Lexical Abilities at 48 Months of Age.*

| | | EV at 48 months |
|---|---|---|
| Deictic Gestures | Age at onset of give | -.772** |
| | Age at onset of show | -.742** |
| | Age at onset of point | -.714** |

**$p$<.01

**Predictors of Intellectual and Vocabulary Abilities at 4 Years of Age**

Previous studies show that early lexical abilities predict later vocabulary and intellectual abilities for children in the general population and children with DD (Perez-

Pereira et al., 2014; Luyster et al., 2007; Stolt et al., 2016; Zampini & D'Odorico, 2011). Another series of studies have shown a predictive value of early gestures, in particular deictic gestures, to later vocabulary and intellectual abilities for children in the general population and children with DD (Ozcaliskan, et al., 2015; Rowe et al., 2008; Rowe & Goldin-Meadow, 2009; Smith, et. al., 2007). In children with WS, two studies have shown significant predictive value based on the growth patterns of EV and rom the achievement of EV milestones to later intellectual abilities and RV (Becerra et al., 2010; Mervis et al., 2003; Robinson & Mervis, 1999). The previous analysis show that deictic gestures development relative to lexical abilities follow a different pattern than TD children or children with DD. In the present analysis I will determine if deictic gestures have a predictive validity to later intellectual validity as it does with other groups of children. In addition, I will analyze the effect of maternal education on vocabulary and intellectual abilities at 4 years of age.

**Method**

*Participants.* Twenty-seven children (12 boys, 15 girls) participated in this study. Mean age at 24 months was 24.45 months (SD = 0.34; range: 23.59 - 24.97 months). At 4 years of age mean was 4.05 years (SD = 0.02, range: 4.00 – 4.08 years).

*Standardized assessments.* The Differential Ability Scales-II Early Years (DAS-II; Elliott, 2007) provides an assessment of general intellectual functioning for children 2½ - 8 years. This measure has six core subtests (Verbal Comprehension, Naming Vocabulary, Picture Similarities, Matrices, Pattern Construction, and Copying) that determine the Early Years General Conceptual Ability SS (GCA, similar to IQ). The DAS-II also provides three cluster SSs: Verbal (Verbal Comprehension and Naming

Vocabulary), Nonverbal Reasoning (Picture Similarities and Matrices), and Spatial (Pattern Construction and Copying). The GCA and the cluster SSs have a mean of 100 and a standard deviation (SD) of 15. The lowest possible SS (floor) is 30 for the GCA and the Verbal cluster, 32 for the Nonverbal Reasoning cluster, and 34 for the Spatial cluster.

The Peabody Picture Vocabulary Test-4, (PPVT-4; Dunn & Dunn, 2007) is a measure of receptive vocabulary for people aged 2½ to 90+ years. In this assessment the tester says a word and asks the child to point to the picture that shows the meaning of the word. The mean PPVT-4 SS for the general population is 100 and the SD = 15. Floor score on the PPVT-4 is 20.

The Expressive Vocabulary Test- 2$^{nd}$ Edition (EVT-2; Williams, 2007) is a measure of single-word expressive vocabulary for children and adults (2½ to 90+ years). It includes nouns, verbs, adjectives, and adverbs. In this assessment, most items require the participant to name the object or action depicted in a picture. For some items, the participant is asked to provide a synonym for a word produced by the examiner. (These items also include a picture.) The mean EVT-2 SS for the general population is 100 with a SD of 15. Floor score on the EVT-2 is 20.

**Procedure**

Early lexical and gestural abilities were determined from the CDI at 24 months of age as described in Chapter II. Children completed a battery of intellectual and language abilities at 4 years of age at the Neurodevelopmental Sciences Lab at the University of Louisville, according to the standardized procedures.

**Data Analysis**

A series of multiple regression analyses was performed to determine the predictability of intellectual and vocabulary abilities at 4 years of age, from lexical and gestural abilities at 24 months and from maternal education level. Considering previous research, maternal education was considered an independent variable in the analyses. This variable was coded as a dichotomous variable, (no bachelor degree vs. bachelor degree). Maternal education level was entered as the first predictor in the models. The second predictor in the analyses was EV size at 24 months of age, as determined from the CDI-WS. The final predictor in the model was deictic gestural ability at 24 months. Deictic abilities at 24 months were coded as 2 if the child was both pointing and showing at 24 months, 1 if the child was either pointing or showing at 24 months, or 0 if the child was neither pointing or showing. This measure of deictic abilities at 24 months of age was entered as the third predictor in the third model for each of the regression analyses.

In these regression analyses, the dependent variables measuring intellectual abilities at 4 years of age were determined from the DAS-II. These dependent variables were: GCA, Verbal Cluster standard score (Verbal SS), Nonverbal Reasoning Cluster standard score (Nonverbal Reasoning SS), and Spatial Cluster standard score (Spatial SS). In addition, PPVT-4 and EVT-2 standard scores (SSs) were considered in the analyses as dependent variables for receptive and expressive vocabulary abilities at 4 years of age.

**Results**

Descriptive statistics for EV at 24 months of age, GCA, Verbal SS, Nonverbal SS, Spatial SS, PPVT-4, and EVT-2 at 4 years are presented in Table 25.

Table 25

*Descriptive Statistics for Independent and Dependent Variables*

| Variable | *M* (SD) | *Mdn* | Range |
|---|---|---|---|
| CDI-WS EV (# of words) | 54.37 (50.18) | 38.00 | 1 - 176 |
| DAS-II GCA | 67.22 (14.39) | 71.00 | 36 - 88 |
| DAS-II Verbal SS | 80.22 (19.15) | 83.00 | 34 - 102 |
| DAS-II Nonverbal Reasoning SS | 80.04 (16.47) | 80.00 | 41 - 106 |
| DAS-II Spatial SS | 58.70 (10.99) | 56.00 | 41 - 88 |
| PPVT-4 SS | 84.44 (22.82) | 91.00 | 34 – 113 |
| EVT-2 SS | 84.48 (21.88) | 92.00 | 20 - 111 |

With regard to deictic gesture abilities, 5 children (18.5% of the sample) neither pointing nor showing at 24 months of age. Seven children (25.9% of the sample) were pointing or showing (but not both), and 15 children (55.6% of the sample) were showing and pointing.

Maternal education was coded as a dichotomous variable. Ten mothers in the sample did not have a bachelor degree (37%), and 17 mothers did have a bachelor degree (63%).

Prior to conducting the analyses, histograms of the variables were constructed and tests of kurtosis and skewness were performed. EV, PPVT-4 SS, and EVT-2 SS failed the tests of normality of distribution, therefore nonparametric correlations were conducted to examine potential relations between EV size at 24 months, deictic gestures at 24 months, maternal education, DAS-II GCA, Verbal SS, Nonverbal Reasoning SS, Spatial SS, PPVT-4 SS, and EVT-2 SS. Results from these correlations are presented in Table 26.

Table 26

*Nonparametric Correlations Between Maternal Education, EV Size, Deictic Gestures, GCA, Verbal SS, Nonverbal Reasoning SS, Spatial SS, PPVT-4, and EVT-2*

| | Spearman's Correlations | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Variables | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1. Maternal Education | .20 | .19 | .18 | .31 | .13 | .06 | .53** | .47* |
| 2. CDI-WS EV size | | .54** | .69** | .64** | .69** | .47* | .78** | .80** |
| 3. Deictic Gestures | | | .61** | .50** | .50** | .59** | .52** | .43* |
| 4. DAS-II GCA | | | | .90** | .89** | .79** | .71** | .70** |
| 5. DAS-II Verbal SS | | | | | .78** | .63** | .68** | .79** |
| 6. DAS-II Nonverbal Reasoning SS | | | | | | .56** | .73** | .70** |
| 7. DAS-II Spatial SS | | | | | | | .46* | .41* |
| 8. PPVT-4 SS | | | | | | | | .86** |
| 9. EVT-2 SS | | | | | | | | |

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

As part of conducting the multiple regression analyses, standardized residuals were examined and the test for normality of residuals (Kolmogorov-Smirnov, KST) was conducted. The assumption of normality of the residuals was met for all measures (Kolmogorov-Smirnov Test, *ps*>.3). In addition, the Variance Inflation Factor (VIF) and tolerance were evaluated to determine multicollinearity of each model. All VIFs were within acceptable limits (<10), as were all tolerance values (>.1).

*Predictors of intellectual ability at 4 years of age*. To test the hypothesis that early lexical and gestural abilities significantly predict intellectual abilities at 4 years of age, three regression models were constructed. The independent variables were maternal education, EV size at 24 months, and deictic gestures at 24 months. The Enter method for multiple regression analysis was performed. Model 1 was compromised of maternal education. EV size was entered in model 2, and deictic gestures was entered in model 3. Results for the multiple regression analysis for GCA are presented in Table 27.

Table 27

*Multiple Regression Analysis for DAS-II GCA*

| | DAS-II GCA | | | |
|---|---|---|---|---|
| Predictors | Adj. $R^2$ | $\Delta R^2$ | β | *p* |
| Model 1: | .01 | .05 | | |
| Mat. Educ. | | | .23 | .250 |
| Model 2: | .37 | .36 | | |
| Mat. Educ. | | | .14 | .389 |
| EV Size | | | .61 | .001 |
| Model 3: | .52 | .16 | | |
| Mat Educ. | | | .09 | .524 |
| EV Size | | | .44 | .006 |
| Deictic Gestures | | | .44 | .007 |

Model 1 did not account for a significant amount of variance in DAS-II GCA, $F$ (1,25) = 1.38, $p$ <.25. Model 2 provided a significant fit to the data, $F$ (2,24) = 8.64, $p$<.001. This model explained 37% of the variance in GCA. In Model 2 maternal education did not predict a significant amount of the variance (β=.23, $t$(27) = .877, ns), however EV size did significantly predict a significant amount of the variance in GCA (β = .61, $t$ (27) = 3.89, p<.001). Model 3 also provided a significant fit to the data, $F$ (3,23)

= 10.49, $p$<.001. The fit in Model 3 was significantly better than the fit of Model 2 ($p$=.007), with an $R^2$ change of .16. Model 3 explained 52% of the variance in GCA. Both EV size and deictic gestures at 24 months were significant predictors of GCA ($p$=.006, and $p$ = .007, respectively). These findings support the hypothesis that EV size and deictic gestures at 24 months of age significantly predict overall intellectual abilities at 4 years of age. Maternal education level did not significantly predict overall intellectual abilities.

To analyze the predictability of specific types of intellectual abilities at 4 years of age, similar multiple regression analyses were performed for the SSs for each of the three DAS-II clusters that contribute to the GCA. Table 28 shows the results for the multiple regression analysis for Verbal SS, Table 29 for Nonverbal Reasoning SS, and Table 30 for Spatial SS.

Table 28

*Multiple Regression Analysis for DAS-II Verbal SS*

| | DAS-II Verbal SS | | | |
|---|---|---|---|---|
| Predictors | Adj. $R^2$ | $\Delta R^2$ | β | *p* |
| Model 1: | .08 | .12 | | |
| Mat. Educ. | | | .34 | .079 |
| Model 2: | .36 | .29 | | |
| Mat. Educ. | | | .26 | .111 |
| EV Size | | | .55 | .002 |
| Model 3: | .49 | .14 | | |
| Mat Educ. | | | .22 | .142 |
| EV Size | | | .39 | .017 |
| Deictic Gestures | | | .41 | .017 |

For the DAS-II Verbal Cluster SS, Model 1 did not account for a significant amount of variance, $F$ (1,25) = 3.35, $p$ <.08. Model 2 provided a significant fit to the data, F (2,24) = 8.40, $p$ = .002). Model 2 explained 36% of the variance of Verbal SS. In Model 2 maternal education did not significantly predict a significant amount of the variability in Verbal cluster SS (β = .26, $t$ (27) = 1.65, $p$=.11). However EV size was a significant predictor (β = .55, $t$ (27) = 2.56, $p$=.002). Model 3 also provided a significant fit to the data, $F$ (3,23) = 9.39, $p$<.001). The fit in Model 3 was significantly better than the fit in Model 2 ($p$<.002), with an $R^2$ change of .138. Model 3 explained 49% of the variance in Verbal SS. Maternal education was not a significant predictor of the variance

($p$=.142). Both EV size and deictic gestures at 24 months were significant predictors of Verbal SS ($p$ = .017, and $p$ = .014, respectively).

Table 29

*Multiple Regression Analysis for DAS-II Nonverbal Reasoning SS*

| | DAS-II Nonverbal Reasoning SS | | | |
|---|---|---|---|---|
| Predictors | Adj. $R^2$ | $\Delta R^2$ | β | $p$ |
| Model 1: | -.02 | .01 | | |
| Mat. Educ. | | | .11 | .582 |
| Model 2: | .40 | .43 | | |
| Mat. Educ. | | | .01 | .940 |
| EV Size | | | .66 | .000 |
| Model 3: | .44 | .06 | | |
| Mat Educ. | | | -.02 | .902 |
| EV Size | | | .56 | .002 |
| Deictic Gestures | | | .27 | .106 |

As shown in Table 29, Model 1 did not provide a significant fit to the data for DAS-II Nonverbal Reasoning SS, $F$ (1,25) = .311, $p$ = .582. Model 2 provided a significant fit to the data, $F$ (2, 24) = 9.66, $p$ <.001. This model explained 40 % of the variance in Nonverbal Reasoning SS at 4 years of age. In Model 2 maternal education did not predict a significant amount of the variability in Nonverbal Reasoning SS ($p$ = .94). However, EV size at 24 months did significantly predict Nonverbal Reasoning SS (β = .66, $t$(27) = 4.33, $p$ =.000). Model 3 also provided a significant fit to the data, $F$ (3,23) =

7.87, $p$ = .001, although the fit provided by Model 3 did not provide a significantly better prediction of the variance than Model 2 ($p$=.106). In Model 3 EV continued to provide a significant prediction ($p$<.002), but neither maternal education nor deictic gestures were significant predictors ($p$ = .902, and $p$ =.106, respectively).

Table 30

*Multiple Regression Analysis for DAS-II Spatial SS*

| | DAS-II Spatial SS | | | |
|---|---|---|---|---|
| Predictors | Adj. $R^2$ | $\Delta R^2$ | β | $p$ |
| Model 1: | -.02 | .01 | | |
| Mat. Educ. | | | .10 | .596 |
| Model 2: | .04 | .10 | | |
| Mat. Educ. | | | .06 | .769 |
| EV Size | | | .33 | .100 |
| Model 3: | .25 | .22 | | |
| Mat Educ. | | | .00 | 1.00 |
| EV Size | | | .13 | .477 |
| Deictic Gestures | | | .51 | .011 |

For the multiple regression analysis for Spatial SS neither Model 1 nor Model 2 provided a significant fit to the data ($F$ (1,25) = .289, $p$ =. 59, and $F$ (2,24) = 1.61, $p$ = .22, respectively). However, Model 3 did provide a significant fit to the data, $F$ (3,23) = 3.94, $p$ = .02, explaining 25% of the variance in Spatial SS. Neither maternal education nor EV size were significant predictors in this model ($p$ = 1, and $p$ = .477, respectively).

However, deictic gestures were a significant predictor of Spatial SS (β = .517, $t$ (27) = 2.77, $p$ =.011).

*Predictors of vocabulary abilities at 4 years of age*. To test the hypothesis that early lexical and gestural abilities significantly predict vocabulary abilities at 4 years of age, two sets of three regression models were constructed. The independent variables were maternal education, EV size at 24 months, and deictic gestures at 24 months. Sequential model multiple regression was performed. Model 1 was compromised of maternal education. EV size was entered in model 2, and deictic gestures was entered in model 3. Results for the multiple regression analysis for PPVT-4 SS are presented in Table 31 and for EVT-2 SS are presented in Table 32.

Table 31

*Multiple Regression Analysis for PPVT-4 SS at 4 Years of Age*

| | PPVT-4 SS | | | |
|---|---|---|---|---|
| Predictors | Adj. $R^2$ | $\Delta R^2$ | β | $p$ |
| Model 1: | .24 | .27 | | |
| Mat. Educ. | | | .52 | .006 |
| Model 2: | .55 | .32 | | |
| Mat. Educ. | | | .43 | .003 |
| EV Size | | | .57 | .000 |
| Model 3: | .63 | .08 | | |
| Mat Educ. | | | .39 | .003 |
| EV Size | | | .45 | .002 |
| Deictic Gestures | | | .32 | .022 |

Model 1 provided a significant fit to the data, *F* (1,25) = 9.19, *p* =.006, explaining 24 % of the variance in PPVT-4 scores. Maternal education was a significant predictor of the variance in PPVT-4, β = .52, *t* (27) = 3.03, *p* = .006. Model 2 also provided a significant fit to the data, *F* (2,24) = 17.13, *p*=.000, explaining 55% of the variance of PPVT-4 scores. The fit in Model 2 was significantly better than in Model 1, with a change in $R^2$ of .31(*p* =.000). Both maternal education and EV size were significant predictors in Model 2, for maternal education β = .43, *t* (27) = 3,27, *p* = .003, and for EV size β = .57, *t* (27) = 4.31, *p* = .000. Model 3 provided a significant fit to the data, *F* (3,23) = 15.95, *p* =.000, and the fit provided by Model 3 was significantly better than the one by Model 2 (*p* = .021), with an $R^2$ change of .08. Model 3 explained 63% of the variance in PPVT-4 standard scores. Within Model 3, maternal education predicted a significant amount of the variance (β = .39, *t*(27) = 3.28, *p* = .003), as did EV size (β = .45, *t* (27) = 3.44, p = .002) and deictic gesture ability at 24 months of age (β = .32, *t*(27) = 2.48, *p* = .021).

Table 32

*Multiple Regression Analysis for EVT-2 SS at 4 Years of Age*

| | EVT-2 SS | | | |
|---|---|---|---|---|
| Predictors | Adj. $R^2$ | $\Delta R^2$ | β | *p* |
| Model 1: | .13 | .16 | | |
| Mat. Educ. | | | .40 | .035 |
| Model 2: | .48 | .35 | | |
| Mat. Educ. | | | .31 | .037 |
| EV Size | | | .60 | .000 |
| Model 3: | .55 | .09 | | |
| Mat Educ. | | | .28 | .046 |
| EV Size | | | .47 | .003 |
| Deictic Gestures | | | .32 | .032 |

Model 1 provided a significant fit to the data, $F$ (1,25) = 4.94, $p$ =.035, explaining 13% of the variation in EVT-2 SS at 4 years. Maternal education level was a significant predictor of EVT-2, β = .40, $t$(27) = 2.22, $p$= .035. Model 2 also provided a significant fit to the data, $F$ (2,24) = 12.94, $p$ =.000, with a change in $R^2$ of .35, explaining 48% of the variance of EVT-2 SS. Both maternal education and EV size contributed significantly to the model, with maternal education β = .31, $t$ (27) = 2.21, $p$=.037, and EV size β = .60, $t$ (27) = 4.2, $p$ =.000. Model 3 provided a significant fit to the data, $F$ (3,23) = 11.87, $p$ =.000, and the fit of Model 3 was significantly better than the one from Model 2 ($p$<.05), with a change in $R^2$ of .09. Model 3 explained 55% of the variance of EVT-2 SS at 4 years. All three dependent variables were found to be significant predictors: maternal education $\beta = .28$, $t$ (27)= 2.10, $p$=.046, EV size $\beta = .47$, $t$ (27) = 3.33, $p$=.003, and deictic gestures, $\beta = .32$, $t$ (27) = 2.28, $p$ =.032.

## Discussion

Three sets of analysis were performed in the present Chapter. The first analysis analyzed longitudinal correlations between early lexical and gestural abilities at 18 months with later lexical and gestural abilities at 30 months. The results form these correlations show a significant relation among lexical and gestural abilities at 18-months with the same abilities at 30-months. Similar results have been found for TD children (Fenson, et al., 1994; Volterra et al., 2005) and for children with ASD (Charman et al., 2003). These findings provide additional evidence for the continuity in gestural and lexical development, not only for TD children but also for children with developmental delay.

The second set of analysis determined strong correlations between the age of onset of deictic gestures with expressive vocabulary at 48 months of age. The findings in the present study, also support previous findings by Mervis and Bertrand (1997) that determined that children with WS start to talk before they point. These results are important for the theories in early language acquisition. During the last four decades, developmental researchers and practitioners have known that most children in the general population and with DD first point before they speak (Bates, 1976). The present study provides important evidence that this developmental timeline does not apply to most children with WS, but the strong correlations with later expressive vocabulary show that deictic gestures are still important for early vocabulary acquisition in children with WS.

The final set of analysis in the present study show that EV size and deictic gestures at 24 months of age significantly predict intellectual and vocabulary abilities at 4 years of age, in children with WS. The results show that EV size at 24 months of age account for 37% of the variance in overall intellectual functioning at 4 years of age. When deictic gesture abilities at 24 months are included in the analysis both EV and deictic gestures account for 52% of the variability of DAS-II GCA scores.

EV size at 24 months, accounts for 36% of the variability of DAS-II Verbal SS. When EV size is combined with deictic gesture at 24 months, they account for 49% of the variability of Verbal SS. DAS-II Nonverbal Reasoning SS was also predicted by EV size at 24 months, with EV size accounting for 40% of the variance, and when deictic gestures were included into the analysis, they both account for 44% of the variance of Nonverbal Reasoning SS. On the other hand, EV size at 24 months, did not significantly predict DAS-II Spatial SS at 4 years. This regression was not significant either, when deictic gestures were included in the analysis.

In addition, the present study show that maternal level of education does not significantly account for variability in intellectual abilities at 4 years of age. Maternal education level were not significant predictors for DAS-II GCA, DAS-II Verbal SS, DAS-II Nonverbal Reasoning SS, or DAS-II Spatial SS.

Nonetheless, with regard to vocabulary abilities, maternal level of education is a significant predictor for both receptive vocabulary, as measured by the PPVT-4, and expressive vocabulary, as measured by the EVT-2. Maternal level of education significantly accounted for 24% of the variance in PPVT-4 SS, and 16% of the variance of EVT-2 scores. This results are similar to the ones by Rowe et al., (2008) with TD children, although in the present study maternal education accounts for a higher percent of the variance than what they reported in TD children (5% of the variance on PPVT scores).

PPVT-4 SS were predicted significantly by EV size and deictic gestures at 24 months of age. EV size when combined with maternal level of education accounted for 55% of the variability of PPVT-4 SS. Furthermore, when deictic gestures were included in the analysis, all three variables accounted for 63% of variability of receptive vocabulary at 4 years of age, measured by the PPVT-4.

With regard to expressive vocabulary, measured by the EVT-2, EV size when combined with maternal level of education accounted for 47% of the variance. When deictic gestures were included 55% of the variance was accounted for by the three predictors.

The results in the present study show that even though deictic gestures in children with WS do not follow the same developmental path as children in the general population and children with DD, these gestural abilities are still very important in the development of receptive and expressive vocabulary.

# CHAPTER V

# GENERAL DISCUSSION

The present dissertation was designed to delineate the characteristics of early lexical and gestural abilities in very young children with WS. Three sets of analyses were performed to provide a deeper understanding of these abilities. The first set of analyses focused on the description of early receptive, expressive, and gestural abilities of children with WS, as determined by parental report on the CDI. The second set of analyses focused on the relations among gestural and lexical abilities. The final set of analyses addressed the predictive value of early lexical and gestural abilities for later intellectual and vocabulary development. In the remainder of this chapter, I summarize and discuss the implications of these findings and consider the limitations of the project and future directions for research.

## Early Lexical Abilities

The present study provided a characterization of early lexical abilities in very young children with WS, as measured by the CDI. The findings, including comparisons to the CDI norms when available, are briefly summarized and related to prior findings in the literature for TD children, children with various types of DD, and children with WS.

### Receptive Vocabulary

RV abilities at 18 months were determined by both the CDI-WG and CDI-WS. At this age, median RV size was 36 words as measured by the CDI-WG and 40 words when measured by the CDI-WS. Great variability was found in RV, with a range from 2 to 129 words for the CDI-WG and from 3 to 146 words for the CDI-WS. A comparison to the CDI-WG norms indicated that RV size was below the 10$^{th}$ percentile for all of the participants, with the majority of children at the 1$^{st}$ percentile.

At 24 months of age the median CDI-WS RV size for the children with WS in the present study was 131 words. Great variability was found as well at this age, with a range of 3 to 308 words. At 30 months of age, median CDI-WS RV was 230 words, with a range of 6 to 524 words. No comparison to same-aged children from the general population was possible because the CDI-WS was not normed for RV.

**Expressive Vocabulary**

At 18 months EV was determined by both the CDI-WG and the CDI-WS. At this age median EV size for the children with WS was 3 words for both measures and EV ranged from 0 to 31 words for both forms of the CDI. All children with WS scored below the 15$^{th}$ percentile on the CDI-WG norms. When compared to the CDI-WS norms all children scored below the 20$^{th}$ percentile with most scoring at or below the 1$^{st}$ percentile.

At 24 months of age median EV size was 21 words as measured by the CDI-WS. EV size ranged from 0 to 176 words. When compared to same-aged children in the general population, all children with WS scored at or below the 25$^{th}$ percentile, with the majority of children scoring at or below the 5$^{th}$ percentile. At 30 months of age median EV size was 75 words, with a range of 0 to 435 words as measured by the CDI-WS. When compared to same-aged children in the general population, all of the participants scored at or below the 25$^{th}$ percentile, with the majority of children below the 5$^{th}$

percentile. These findings for 24- and 30-month-olds replicate those of Mervis and Robinson (2000), who studied a much smaller sample of young 2-year-olds with WS.

## Gestural Abilities

The present study provides a general characterization of gestural abilities in children with WS at 18, 24, and 30 months of age. Gestural abilities were determined from the CDI-WG, which only provides norms for children up to 18 months of age. Therefore, no comparison to the norms could be made for 24- and 30-month-olds.

### Early Gestures

In the present study the18-month-olds with WS had a median of 9 gestures on the EG measure, with a range from 1 to 15 gestures (out of 18 possible). When compared to the norms for the general population, most children scored below the 5$^{th}$ percentile, although two scored at the 45$^{th}$ percentile.

At 24 months of age, median EG was 13 gestures, with a range of 2 to 18 gestures. Median EG for 30-month-old children was 15, with a range of 3 to 18 gestures. These results suggest a significant delay in acquisition of early gestures.

Parental responses to the first three items in the First Communicative Gestures section of the CDI were used to determine the age of onset of deictic gestures for 39 children with WS who were part of a longitudinal study. Mean age of onset of giving was 20.49 months (median = 19.25 months), mean age of onset of showing was 21.47 months (median = 20.86 months), and mean age of onset of pointing was 25.25 months (median: 23.50). Five children had not begun to point by 48 months of age and two children had not begun to show objects by 48 months. These results present evidence for a significant delay in acquisition of deictic gestures by children with WS.

**Late Gestures**

The 45 items that compose the LG component of the CDI-WG include a series of symbolic gestures and symbolic play behaviors that appear somewhat later in development for children in the general population, when compared with the onset of behaviors in the EG section (Fenson et al., 1994, 2007). The 18-month-old children in the present study had a median LG at 18 months of 11, with a range between 1 and 27 gestures. When compared to the norms for the general population, all children with WS were at or below the 15$^{th}$ percentile, with most children below the 3$^{rd}$ percentile.

At 24 months of age children with WS had a median of 20.5 LG, ranging from 2 to 41 gestures. At 30 months of age, the children in the present study had a median of 28 LG with a range between 5 and 42 gestures. These results show a significant delay in symbolic gestures and symbolic behavior in children with WS.

**Total Gestures**

The measure of total gestures is a combination of EG and LG (for a maximum possible of 63). The 18-month-olds with WS in the present study had a median of 18 TG, ranging from 3 to 42. When compared to the norms for the general population, all participants scored below the 20$^{th}$ percentile, with most children at or below the 1$^{st}$ percentile.

At 24 months of age children with WS had a median of 32.5 TG, ranging from 5 – 59 gestures. At 30 months of age, the participants had a median of 43 TG with a range between 8 to 60. These results document a significant delay in the acquisition of both communicative and symbolic gestures by children with WS.

In summary, the present study replicates previous findings of significant delay in the acquisition of early receptive and expressive vocabulary by young children with WS (Mervis et al., 2003; Singer Harris et al., 1997; Thal et al., 1989). The present findings characterize the amount of the delay in lexical abilities for children with WS relative to children in the general population. In addition, the present study provides the first description of early gestural abilities in a large sample of very young children with WS. Comparison of gestural abilities to the norms for 18-month-olds in the general population provides evidence of significant delay in the development of deictic gestures, conventional gestures, symbolic gestures, and symbolic behavior in young children with WS.

**Relations Between Gestural and Lexical Abilities**

Studies of early language development have analyzed the link between gestures and lexical abilities. Some studies have found concurrent correlations between gestures, RV, and EV (Fenson et al., 1994), while other studies have looked at longitudinal correlations among gestures, RV, and EV (Iverson & Goldin-Meadow, 2005; Sundvist et al., 2016). The overall finding of these studies of children in the general population is that in early development gestural and lexical abilities develop in synchrony and are related to each other. Iverson and Goldin-Meadow (2005) suggest a developmental path for gestures and expressive vocabulary in which children begin to communicate mainly by gestures, then evolve to gesture + word combinations, and then advance to word + word combinations, without ever dropping the use of gestures. These authors suggest that gestures facilitate the development of expressive vocabulary.

**Concurrent Correlations between Lexical and Gestural Abilities**

Considering the significant delay in early lexical and gestural development for children with WS, the present study analyzed if concurrent correlations between these abilities are present in children with WS. Significant concurrent correlations were found between EV, RV, EG, LG, and TG at 18, 24, and 30 months of age. These results, in conjunction with previous findings from studies of children with ASD (Charman et al., 2003) and DS (Zampini & D'Odorico, 2011), provide additional evidence of the link between gestures and lexical abilities during early development not only for children in the general population (Bates et al., 1979; Fenson et al., 1994; Sundvist et al., 2016) but also for children with a variety of types of DD.

Another series of analyses in the literature addressed interrelations between lexical abilities and gestural abilities as measured by the CDI-WG. These studies considered the characteristics of EV within the context of RV, as well as gestural abilities (EG, LG, and TG) within the context of both RV and EV. The present study compared the proportion of children with percentile ranks below the $50^{th}$ percentile vs. the proportion of children at or above the $50^{th}$ percentile for each interval of lexical abilities, considering its relation with another lexical or gestural ability. EV was first analyzed in the context of RV. Results indicate that there was a higher proportion of children with WS with a percentile ranking at or above the $50^{th}$ percentile than expected in comparison to the general population, for RV above 50 words. Charman et al. (2003), who analyzed EV within the context of RV in children with ASD, also reported higher EV size for a given RV interval, although these results need to be interpreted cautiously, because they are based on means rather than medians.

These results have two possible nonexclusive explanations. One possible explanation is that the parents are underestimating RV abilities in children with WS, which has been a concern with measures like the CDI for very young TD children (Tomasello & Mervis, 1994). I think that when a child starts to talk, after a lot of anticipation from the parent of a child with a DD, it is more difficult for the parent to focus on what the child understands separately from what the child says. On the other hand, considering the personality profile of children with WS, which describes them as being socially disinhibited, it is possible that these children are saying more words than what would be predicted based on RV. These possible interpretations are based on the preliminary findings reported in this study. Further analysis with a larger sample will show if this difference in proportion between split halves holds true for children with WS.

The present study also considered children's gestural abilities in the context of RV. For EG, LG, and TG significantly more children than expected scored at or above the $50^{th}$ percentile for a given RV size, for most RV intervals. To interpret these results, one needs to consider the ages at which the children with WS reached each of the RV sizes (refer to Table 12). Most children with RV above 50 words are at least 24 months of age.

The items measured in EG (games and routines, conventional gestures, some deictic gestures) and in LG (imitating others, pretending to be a parent) are behaviors that may be explicitly taught to these children as part of social play and play interactions, including those involving early intervention staff. The dissociation norms for the CDI-WG were based on children in the general population under 18 months of age. Children with WS are developing these behaviors considerably later so they have had more time to play and experience social encounters to learn these behaviors in comparison to the amount of exposure that children in the general population have. Therefore, these results likely do not suggest that there is an advantage of gestural abilities within the context of RV for children with WS. Instead, it may just be that after considerable experience children with WS have been able to learn these behaviors.

Gestural abilities also were analyzed within the context of EV. A larger percentage of children than expected was above the $50^{th}$ percentile for EG when EV was above 20 words, even though the median percentile was 65 for the EV interval between 21 – 50 words and 57 for the EV interval between 51 – 100 words. Larger samples are needed to determine if the significant differences obtained in this study hold true. No significant differences were found for LG in the context of EV. These results suggest that for a given EV size, children with WS are producing a similar number of different gestures as are children in the general population. As explained in the previous section, I think EV size is a better representation of the lexical abilities of children with WS than RV because parents may tend to underestimate receptive vocabulary abilities.

**Longitudinal Relations between Lexical and Gestural Abilities**

In order to address the longitudinal relations between gestural and lexical abilities, two different analyses were performed. The first analysis considered correlations between RV, EV, EG, and TG at 18 months of age to the same lexical and gestural abilities at 30 months of age. Significant longitudinal correlations were found between all measures of lexical and gestural abilities. Similar results were reported recently between 9 months of age and 16 months of age in a sample of TD children in Sweden (Sundvist et al., 2016).

These results provide additional evidence of the link during early development between lexical and gestural abilities.

Various research groups have addressed the question of how gestures are tied to language during early development. Goldin-Meadow and colleagues (e.g., Goldin-Meadow, 2000, 2007; Iverson & Goldin-Meadow, 2005) have provided evidence that gestures emerge prior to expressive vocabulary. Adamson and colleagues (Adamson, 1995; Ozcaliskan, et al., 2015) also have analyzed the relation between gestures and lexical abilities, focusing primarily on the role of deictic gestures and expressive vocabulary. These studies have determined that for TD children, deictic gestures appear before the onset of expressive vocabulary. In children with ASD, Ozcalizcan et al. (2015) found a significant correlation between onset of deictic gestures (pointing and showing) and later vocabulary abilities, as measured by the EVT (Williams, 1997). Smith et al. (2007), in a group of children with ASD, found significant differences in EV growth between children who were producing deictic gestures at the beginning of the study when compared to the children who were not pointing at the beginning of the study. Mervis and Bertrand (1997) showed that children with DS follow the same path as TD children (beginning to point prior to beginning to speak or sign), but almost all children with WS begin to talk before they point. In the present study, all but one child began to talk before beginning to produce deictic pointing gestures.

Even though children with WS begin to talk before they begin to produce deictic gestures, the correlations between age of onset of give, show, and point with EV abilities at 48 months of age are significant and strong. These results suggest that children with

WS who point earlier relative to other children with WS have better expressive vocabulary at 48 months.

The results in the present study show that children with WS do not follow the same path of gestures and expressive vocabulary as most children in the general population and most children with DD, but that deictic gestures are still important for the development of expressive vocabulary in children with WS. Considering that joint attention to the referent is required for a child to learn the label to an object, the present results raise the question of how joint attention between children with WS and their communicative partners is established in order for the children to acquire vocabulary. Mervis and Bertrand (1997) suggest that there are alternate methods to establish joint attention to elicit lexical development. In their study three alternate methods of establishing joint attention were identified: (1) parent follows child's focus of attention and then labels the object, (2) parent moves the object to where the child is looking and then labels it, or (3) parent directs child's attention to the object by tapping it. Further research should examine parent child interaction to confirm Mervis and Bertrand's preliminary analysis. If these results hold, alternate methods of establishing joint attention should be considered in early intervention programs focused on children with WS.

On the other hand, when trying to understand why children with WS are not producing deictic gestures prior to beginning to talk, it is important to keep in mind the behavioral and cognitive profile associated with WS. Could these children have difficulty producing deictic gestures due to their weakness in visuospatial processing? Or could it be that they are more interested in faces and dyadic social interaction than in objects?

Further research is needed to understand why children with WS acquire deictic gestures later than expected.

## Predictors of Vocabulary and Intellectual Abilities at 4 Years of Age

The final analyses in the present dissertation addressed the predictive value of early lexical abilities, gestural abilities, and maternal level of education for later vocabulary and intellectual functioning in children with WS at 4 years of age. Considering previous findings from the general population and children with DD, and the previous findings in the present dissertation, a series of multiple regression analyses was performed to determine the predictive value of deictic gestural abilities at 24 months of age, EV size at 24 months of age, and maternal level of education for intellectual abilities (as determined from the DAS-II), expressive vocabulary (measured by the EVT-2), and receptive vocabulary (measured by the PPVT-4) at 4 years of age.

Preliminary bivariate correlation analyses showed significant correlations among deictic gestures at 24 months, EV size at 24 months, DAS-II GCA, DAS-II Verbal SS, DAS-II Nonverbal Reasoning SS, DAS-II Spatial SS, PPVT-4 SS, and EVT-2 SS at age 4 years. Maternal education level only correlated significantly with PPVT-4 SS and EVT-2 SS at 4 years of age.

Findings from the regression analyses indicated that all three predictors made significant independent contributions to the receptive vocabulary (PPVT-4) and expressive vocabulary (EVT-2) abilities of children with WS at 4 years of age. EV size and deictic gestures at 24 months of age accounted for a significant amount of variance in overall intellectual abilities and verbal abilities at 4 years of age. EV size at 24 months accounted for a significant amount of variance in Nonverbal Reasoning abilities at 4 years. Deictic gestures at 24 months of age accounted for a significant amount of variability in spatial abilities in children with WS at 4 years.

The results of these correlational analyses for children with WS are consistent with previous results for children with TD and children with DD. In TD children, Bornstein and Haynes (1998), found significant relations between EV at 20 months and intellectual abilities at 48 months. Reese and Read (2000) found significant significant relations between EV at 1;7 years and both PPVT-III SS and EVT SS at 2;8 and 3;4 years. In addition, Rowe et al. (2008) found significant correlations between gestures at 14 months of age and PPVT-III SS at 42 months of age.

With regard to the role of maternal education, Rowe et al. (2008) found that maternal education was a significant predictor of child receptive vocabulary as measured by the PPVT-III SS. In children with WS, Mervis et al. (2012) found a significant effect of maternal education level on child Verbal SS as measured by the KBIT-2, but not on KBIT-2 Nonverbal SS.

Previous findings in children with ASD (Luyster et al., 2007) showed that RV size and EV size at 2 years of age accounted for a significant amount of variance in expressive language at 9 years and that LG at 2 years significantly predicted verbal IQ, expressive language, and adaptive behavior at 9 years of age. Ozcaliskan et al. (2015) found a significant correlation between deictic gestures at a median age of 31 months and EVT scores one year later. In children with WS, Mervis and colleagues (Mervis, 2004; Mervis et al., 2003; Robinson & Mervis, 1999) determined that patterns of early EV growth are related to later receptive vocabulary (PPVT-III) and intellectual functioning (DAS-Preschool) at 4 years of age

Findings for children with DD are important not only to address theoretical positions regarding the relations between the onset of deictic gestures and the onset of lexical abilities, the relations between early gestural and lexical abilities to later intellectual functioning, or the developmental continuum of language abilities. These results are important from an applied perspective as they provide strong evidence for the importance of early intervention for children with DD and suggest the importance of focusing early intervention on developing early receptive and expressive lexical abilities and the comprehension and production of deictic gestures.

## Limitations

Although the sample size of the present study was large in comparison to previous studies of the early language development of children with WS, it was still relatively small. A larger sample size would provide the power needed for a more detailed investigation of the predictive value of early gestural and lexical abilities at 24 months and maternal education level for later intellectual and vocabulary abilities.

Generalization regarding the receptive vocabulary abilities of children with WS is limited by the fact that the CDI-WS does not provide norms for receptive vocabulary abilities from the general population. The hypothesis that parents of children with WS are underestimating RV abilities cannot be tested due to the fact that norms are unavailable to compare at older ages.

The dissociation analyses were limited both by sample size and by characteristics of the norms. The dissociations between lexical and gestural abilities should be analyzed further in a larger sample of children with WS, with the distribution of percentiles across quartiles considered rather than a median split. The dissociation norms provide limited differences in the number of EG between the different percentile ranks, with the result that the same number of EG often corresponded to multiple percentile ranges. Therefore, depending on how the data are classified the child could be assigned different percentile rankings. In the present study all children were given the highest percentile ranking associated with their EG size. In future studies, assignment of the median percentile when the same EG is assigned to multiple percentile rankings for RV or EV should be considered.

## Implications

The present study provides a clear characterization of the amount of variability and delay of early lexical and gestural abilities in 18-, 24-, and 30-month-old children with WS, supporting previous findings (Mervis et al., 2003) regarding the delay of early lexical abilities in children with WS. From a theoretical perspective, the present findings provide evidence for the continuity of early gestural development, receptive vocabulary, and expressive vocabulary with later receptive vocabulary, expressive vocabulary and overall intellectual functioning at 4 years of age. The results presented in this study, in children with WS, are in line with previous results reported for TD children (Reese & Read, 2000; Rowe et al; 2008) and children with DD (Luyster et al., 2007; Stolt et al., 2016). Rowe and Goldin-Meadow (2009) argue that early gesture use is linked to later word learning, and that this link is universal.

On the other hand, the theory that onset of deictic gestures universally precedes the onset of expressive vocabulary (Adamson, 1995) does not hold for children with WS. The present study provides additional evidence that most children with WS begin to talk before they point. Therefore, onset of pointing before onset of expressive vocabulary is not universal. Mervis suggested that the argument that referential pointing should precede onset of expressive vocabulary was based on the attention-directing function of pointing. Thus, in this argument pointing is a proxy for shared joint attention to an object, and it is shared joint attention to the object being labeled that is critical for the child to begin to acquire a lexicon (Mervis & Bertrand, 1997; Mervis, 2006).

Considering the present findings, therapist addressing early language acquisition in children with WS should focus on goals to develop receptive and expressive vocabulary and to teach the use of deictic gestures early in development. If a significant amount of variance in later intellectual functioning, including spatial abilities (the area of greatest weakness for children with WS) can be accounted for by variance in early use of deictic gestures and expressive vocabulary size, an emphasis on learning to use deictic gestures at an earlier age as well as on increasing vocabulary may facilitate not only language development but also the development of other types of intellectual abilities.

The present study predicted variance in intellectual functioning at 4 years of age, from lexical and gestural abilities at 24 months of age. At 4 years of age, preschool children with WS are establishing the intellectual and language structure needed to be successful for later schooling. It is important that more emphasis be placed on high-quality early intervention if the goal for practitioners and parents is to have a child ready for the intellectual and linguistic challenges that the school years bring.

## Future Directions

Findings from the present study suggest a series of questions open to further research. An important focus for future research would be to further analyze the alternate ways in which communicative partners establish joint attention in children with WS.

Periods of joint attention are crucial for language acquisition. Future studies should analyze parent-child interactions to determine alternate methods and how they are related to vocabulary development.

Another series of analyses that would be a follow up of the present study would be to address the possibility of links between lexical, gestural, and grammatical abilities as measured by the CDI-WS Sentence Complexity section. These analyses could provide further evidence for the link between gestures, lexicon, and grammar, not only for children in the general population but also for children with DD, including children with WS.

In addition, the concurrent validity of CDI EV for children with WS at age 4 years should be determined. Concurrent correlation analysis between CDI-WS EV size and EVT-2 SS would be valuable. Similar analyses with CDI-WS RV and PPVT-4 SS could be performed.

Finally, to further address the findings of this research project the relation between visuospatial processing and early deictic gestures in children with WS should be investigated. Correlation analyses focusing on the relation between Mullen Scales of Early Learning (Mullen, 1995) Fine Motor raw score at 24 months of age and concurrent deictic gesture abilities as measured in the present study would begin to address this question.

In summary, the present study presents additional evidence for delay in early receptive and expressive vocabulary in very young children with WS. In addition, this project describes the delay in development of gestural abilities in genera, and in particular the delay in the onset of deictic gestures. Through concurrent and longitudinal correlation analyses, results support the theory of a universal link between gestural and lexical abilities early in development. On the other hand, analysis of the age of onset of deictic gestures in comparison with the age of onset of EV provides additional evidence that children with WS begin to talk before they produce deictic gestures. Nevertheless, deictic gestural abilities are still strongly related to later expressive vocabulary abilities. Final analyses provided evidence of the strong predictive value of early receptive vocabulary, early expressive vocabulary, and early deictic gestural abilities at 24 months, for intellectual and vocabulary abilities at 4 years of age. In addition, maternal education level independently predicted a significant amount of the variability in receptive and expressive vocabulary abilities. The pattern of results provides strong evidence for the importance of early intervention for very young children with WS, with a focus on developing receptive and expressive vocabulary and on facilitating the comprehension and production of deictic gestures.

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**Universidad de Los Andes**
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**Professional Experience**

| | | |
|---|---|---|
| Graduate Research Assistant | 2006 – 2012<br>2015- Present | University of Louisville<br>Neurodevelopmental<br>Sciences Lab |
| Graduate Research Assistant | 2005 – 2006 | University of Louisville.<br>Infant Cognition Lab |
| Graduate Teaching Assistant | Spring 2005 | University of Louisville<br>Cognitive Processes |
| Graduate Research Assistant | 2001 – 2004 | University of Louisville<br>Neurodevelopmental<br>Sciences Lab |
| Lecturer | 1999–2000 | Universidad de Los Andes<br>Departamento de Psicología<br>Bogotá, Colombia. |
| Professional Research Assistant | 1999-2000 | Universidad de Los Andes,<br>Departamento de Psicología<br>Bogotá, Colombia |
| Developmental Psychologist | 1999- 2000 | CEINF [Child Stimulation<br>Center]<br>Bogotá, Colombia. |
| Psychologist | 1999 | Fundación del Quemado<br>[Foundation for the Burned]<br>Bogotá, Colombia. |

**Practicum**

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| Fundación Cardio-Infantil / Instituto de Cardiología<br>Bogotá, Colombia. | 1998 |
| Fundación Liga Central contra la Epilepsia<br>Bogotá, Colombia. | 1997 |
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**Publications**

Mervis, C.B., & Becerra, A.M. (2007). Language and communicative development in Williams syndrome. *Mental Retardation and Developmental Disabilities Research Reviews, 13*, 3-15.

Mervis, C. B., Becerra, A. M., Rowe, M. L., Hersh, J. H., Morris, C. A. (2005). Intellectual abilities and adaptive behavior of children and adolescents with Kabuki Syndrome: A preliminary study. *American Journal of Medical Genetics, 132A*, 248-55.

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**Conference Presentations**

Becerra, A. M., & Mervis, C. B. (2012, July). *Language and cognitive abilities of very young children with Williams syndrome.* Platform presentation at the Williams Syndrome Association National Convention. Boston, MA.

Cashon, C. H., Denicola, C. A., Ha, O-R., Becerra, A. M. (2011, April). *2 to 3 year olds with Williams Syndrome form novel word object associations.* Poster presented at the Society for Research in Child Development. Montreal, CA.

Becerra, A. M. (2010, June). *Relations between early linguistic milestones and intellectual abilities at age 4 years for children with Williams syndrome.* Poster presented at the Symposium on Research on Child Language Disorders. Madison, WI.

Henderson, D. R., Becerra, A. M., John, A. E., & Mervis, C. B. (2010, June). *Language abilities in toddlers with Williams syndrome: Performance on the CDI-III.* Poster presented at the Symposium on Research in Child Language Disorders, Madison, WI.

Becerra, A. M., John, A. E., Peregrine, E., & Mervis, C. B. (2008, June). *Reading abilities of 9-17-year-olds with Williams syndrome: Impact of reading method.* Poster presented at the Symposium on Research on Child Language Disorders. Madison, WI. Also presented at the International Professional Meeting of the Williams Syndrome Association, July 2008, Anaheim, CA.

John, A. E., Becerra, A. M., Peregrine, E., Mervis, C. B. (2008, June). *Variability of language abilities of 4-year-olds who have Williams syndrome.* Poster presented at the Symposium on Research on Child Language Disorders. Madison, WI. Also presented at the International Professional Meeting of the Williams Syndrome Association, July 2008, Anaheim, CA.

Becerra, A.M. (2008, July). *Que es el Síndrome de Williams? [What is Williams syndrome]*. Platform presentation at the Williams syndrome Association National Convention. Anaheim, CA.

Becerra, A. M., & Mervis, C. B. (2008, July). *Patterns of early language development of children with Williams syndrome*. Poster presented at the International Professional Meeting of the Williams Syndrome Association, Anaheim, CA.

Mervis, C. B., Velleman, S. L., John, A. E., Currier, A., Peregrine, E., Becerra, A. M., & Morris, C. A. (2008, July). *Intellectual and behavioral characteristics of individuals with Williams syndrome or duplication of the Williams syndrome region.* Platform presentation at the International Williams Syndrome Association Professional Conference, Anaheim, CA

Robinson, B. F., Mervis, C. B., Hutchins, S. G., Becerra, A. M., Rowe, M. L., & Vasudeva, A. (2005, April). *Early lexical development and later language and cognitive abilities of children with Williams syndrome or Down Syndrome.* Poster presented at the Symposium on Research in Child Development, Atlanta, GA.

Mervis, C. B., Robinson, B. F., Hutchins, S. G., Becerra, A. M., Rowe, M. L., & Vasudeva, A. (2004, July). *Relations between early lexical development and later language and cognitive abilities*. Platform presentation at the International Professional Meeting of the Williams Syndrome Association, Grand Rapids, MI.

Becerra, A. M., Rowe, M. L., Robinson, B. F., & Mervis, C. B. (2003, April). *Patterns of early language acquisition by young children with Williams syndrome*. Poster presented at the Society for Research in Child Development, Tampa, FL.

Rowe, M. L., Becerra, A. M., Hanes, J. A., & Mervis, C. B. (2003, April). *Use of pragmatic cues in word learning by young children with Williams syndrome.* Poster presented at the Society for Research in Child Development, Tampa, FL.

Rowe, M. L., Becerra, A. M., & Mervis, C. B. (2003, April). *Empathy in 4-year-olds with Williams syndrome*. Poster presented at the Symposium on Research in Child Development, Tampa, FL.

Becerra, A. M. (2002, July). *Síndrome de Williams: Aspectos médicos, psicológicos y educativos [Williams syndrome: Medical, psychological and educational aspects]*. Platform presentation at the Williams Syndrome Association 2002 National Convention, Long Beach, CA.

Becerra, A. M., Rowe, M. L., Robinson, B. F., & Mervis, C. B. (2002, July). *Patterns of early language acquisition of children with Williams syndrome.* Poster presented at the International Association for the Study of Child Language/ Symposium on Research in Child Language Disorders joint conference, Madison, WI. Also presented at the International Professional Meeting of the Williams Syndrome Association, July 2002, Long Beach, CA.

Rowe, M. L., Becerra, A. M., & Mervis, C. B. (2002, July). *The development of empathy in four-year-old children with Williams syndrome*. Platform presentation at the International Professional Meeting of the Williams Syndrome Association. Long Beach, CA.

Mervis, C. B., Rowe, M. L. & Becerra, A. M. (2002, July). *Longitudinal analyses of intelligence and receptive language abilities of individuals with Williams syndrome.* Platform presentation at the International Professional Conference of the Williams Syndrome Association, Long Beach, CA.

Becerra, A. M. (2002, November). *Síndrome de Williams: Aspectos médicos, psicológicos y educativos [Williams syndrome: Medical, psychological and educational aspects].* Platform presentation at the Williams Syndrome Association Regional Convention, Naples, FL.

Rowe, M. L., Lukjan, M., Becerra, A. M., & Mervis, C. B. (2001, April). *Empathy in 4-year-old children with Williams syndrome*. Poster presented at the Annual Spring Conference of the Kentucky Psychological Association, Louisville, KY.

Becerra, A. M., Rowe, M. L., Robinson, B. F. & Mervis, C. B. (2001, August). *Patterns of early language development of children with Williams syndrome.* Platform presentation at the National Science Foundation Workshop on Separability of cognitive functions: What can be learned from Williams syndrome? Amherst, MA.

Rowe, M. L., Lukjan, M., Becerra, A. M., & Mervis, C. B. (2001, August). *Empathy in 4-year-old children with Williams syndrome.* Platform presentation at the National Science Foundation Workshop on Separability of cognitive functions: What can be learned from Williams syndrome? Amherst, MA.

Becerra, A. M. (1999, June). *Intervención psicológica del niño quemado [Psychological intervention for burned children].* Platform presentation at the XIII National Course of Burns, XXVII National Congress of Plastic Surgery, Bogotá, Colombia.

**Membership in Professional Organizations:**

American Association on Intellectual and Developmental Disabilities (AAIDD)
American Psychological Association (APA)
Williams Syndrome Association (WSA)