5-2013

The development of word-object associations in typically developing infants and infants and toddlers with Williams syndrome.

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THE DEVELOPMENT OF WORD–OBJECT ASSOCIATIONS IN TYPICALLY DEVELOPING INFANTS AND INFANTS AND TODDLERS WITH WILLIAMS SYNDROME

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A Dissertation
Submitted to the Faculty of the
College of Arts and Sciences of the University of Louisville
In Partial Fulfillment of the Requirements
For the Degree of

Doctor of Philosophy

Department of Psychological and Brain Sciences
University of Louisville
Louisville, KY

May 2013

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ACKNOWLEDGEMENTS

Working on the Ph.D. has been an extraordinary and often challenging experience. There have been days and nights struggling with data, writing, sleep deprivation and pains, but those also have been filled with joy of research, learning, and especially support from my significant others that made this dissertation possible. I would like to express my sincere appreciation for their contributions in making the time working on my Ph.D. an invaluable and memorable experience.

First of all, I am sincerely and deeply grateful for my advisor, Dr. Cara Cashon, who has been always there for me past six years with excellent mentorship and incomparable encouragement. Without your advice, time, and support, I could not have completed any of the steps along the way in pursuit of my Ph.D. Thank you for your thoughtfulness and understanding of my tough circumstances, which made this journey successful. You have the warmest hugs.

My sincere gratitude is also reserved for Dr. Carolyn Mervis and Dr. John Pani. Thank you for being there for me, and your support means a lot to me. I am grateful for Dr. Carolyn Mervis for her sincere encouragement and invaluable opportunities for research collaboration that enabled me to complete this dissertation. Dr. John Pani also has contributed his time, insightful comments, and provided encouragement for my preliminary exam and this dissertation project.

I am also very grateful for Dr. Keith Lyle and Dr. Guy Dove for their time, support, and insightful comments that made this dissertation project even better.

I send a very special thanks to all of the members of the Infant Cognition Lab as well as the Neurodevelopmental Sciences Lab for their help with data collection and support, especially to Nick Holt and Chris DeNicola for overseeing parts of this project when I was not available, and for making life in the graduate school enjoyable.

I sincerely appreciate all the families who participated in this dissertation project. Without their participation, this project could not be completed.

I also send a special thanks to my friends and faith families for providing me wonderful support and prayer.

My debt of gratitude goes to my family. I am sincerely grateful for my parents, Chan-Hong Ha and Kwang-Ja Kim, for always believing in me and supporting me, and my parents-in-law, Eu-Iil Lim and Sun-Yul Kim, for supporting me with ceaseless prayer. Deeply thankful for my husband, Seung-Lark Lim, for his incredible support and trust. Without him, I could not have done any of these. My biggest thanks and deepest apologies go to my lovely children, Ian Lim and Ella Lim, who had to wait too long to get together with their daddy because of mommy's pursuing her Ph.D. They are true blessings in my life.

Finally, but most importantly, thank you Lord for all you have done for me. I can do everything though him who gives me strength.

ABSTRACT

THE DEVELOPMENT OF WORD–OBJECT ASSOCIATIONS IN TYPICALLY DEVELOPING INFANTS AND INFANTS AND TODDLERS WITH WILLIAMS SYNDROME

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April 22, 2013

The ability to form associations between words and objects rapidly with a short amount of exposure is a marker of more proficient word learners in typically developing (TD) infants. Investigating the underlying mechanisms for how words are associated with objects is necessary for understanding early word learning in the TD population as well as in people with Williams syndrome (WS), a rare neurogenetic developmental disorder characterized by language delay in early development.

The findings in the present study showed a developmental difference in the ability to form word–object associations between 12 and 14 months of age in TD infants. It was indicated that whereas TD 12-month-old infants predominantly processed objects, TD 14-month-old infants processed objects, words, and word–object associations. The developmental pattern found with the participants with WS was very similar to that found in the TD infants. The findings indicated that toddlers with WS develop the ability to rapidly learn word-object associations as early as 2 years of age. Whereas 1-year-olds

with WS processed objects and words, 2-year-olds with WS processed objects, words, and word–object associations. These patterns suggested that infants and toddlers with WS may go through similar developmental changes in learning word–object associations as TD population, though their language development is delayed.

The findings provided evidence of underlying mechanisms of early word learning in both TD infants and infants and toddlers with WS. In the present study on learning word–object associations, a domain-general developmental progression from an independent to an integrated level of processing was found. In both TD infants and infants and toddlers with WS, novice word learners, who were in the independent processing phase, mainly processed the word and/or object information, but processed them independently of one another. In contrast, intermediate word learners processed associative information between words and objects, as well as the word and object information. This developmental progression was consistent with Cohen's information processing approach to infant cognitive and perceptual development.

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CHAPTER I

GENERAL INTRODUCTION

Language acquisition begins early in life, but takes a substantial amount of time to develop. In typically developing (TD) infants, a growth spurt in receptive vocabulary (i.e., comprehension), marked by acquiring the first 50 – 100 receptive words, is not found until infants are around 12 – 14 months of age (Benedict, 1979; Golinkoff & Hirsh-Pasek, 2006; Mills, Coffey, & Neville, 1993). Expressive vocabulary (i.e., production) undergoes a vocabulary spurt, whereby infants have acquired 50 – 100 expressive words, around 18 – 20 months of age (Benedict, 1979; Fenson et al., 2007; Goldfield & Reznick, 1990; Torkildsen et al., 2008; Woodward, Markman, & Fitzsimmons, 1994). Thus, TD infants are becoming more proficient word learners after the first year of life (e.g., Fernald, Pinto, Swingley, Weinberg, & McRobets, 1998; Gopnik & Meltzoff, 1987).

Infants and toddlers with Williams syndrome (WS), a rare neurodevelopmental disorder caused by a deletion of ~25 genes on one copy of chromosome 7q11.23 (Hillier et al., 2003), have delayed language in their early development. Adolescents and adults with WS show a characteristic profile featured by intellectual disabilities in the borderline to moderate range, with a distinctive weakness in visuospatial construction, but a relative strength in face processing, verbal short-term memory, and language (Howlin, Davies, & Udwin, 1998; Howlin, Elison, Udwin, & Stinton, 2010; Mervis & John, 2012; Mervis, Robinson, Bertrand, Morris, Klein-Tasman, & Armstrong, 2000). Young children with WS do not exhibit an expressive vocabulary spurt, that is, acquiring the first 50 – 100 expressive words, until around 3 years of age (Mervis, 2012). Some have posited that language development in WS is delayed, but most aspects in language acquisition may follow the same developmental trajectory as those in the TD population (Mervis & John, 2012).

Given the language delays in individuals with WS, it is important for us to better understand early word learning in this population. Emergence of the ability to rapidly form associations between words and objects, a precursor to referential word learning (Nazzi & Bertoncini, 2003), has been regarded as evidence that infants are becoming more proficient word learners (Marcus, Fernandes, & Johnson, 2012; Werker, Cohen, Lloyd, Casasola, & Stager, 1998). Ultimately word learning involves more than forming mappings between words and perceptual concepts (e.g., Preissler & Carey, 2004). However, forming associations is thought to be a necessary mechanism to master language (Marcus, Fernandes, & Johnson, 2012; Waxman & Gelman, 2009). Thus, being able to make associative links between words and objects is an important early step in word learning (Golinkoff & Hirsh-Pasek, 2006; Oviatt, 1980). To understand how children with WS learn words, it is necessary to understand the mechanisms underlying early word learning in the TD population, in particular, how TD infants come to associate words with objects.

The present study is aimed at investigating the mechanisms that underlie the developing ability to form word–object associations in TD 12- and 14-month-old infants (Experiment 1). A second purpose of the present study is to explore the mechanisms used by those who experience delays in language acquisition, in particular, infants and toddlers with WS ages 1–1.99 years and 2–2.99 years (Experiment 2).

Word–Object Associations in Typically Developing Infants

For the past three decades, researchers have shown interest in investigating how TD infants come to associate words with objects. The most common method used to investigate word–object associations in TD infants is the switch paradigm (e.g., Werker et al., 1998; Werker, Fennell, Corcoran, & Stager, 2002).

Werker et al. (1998) reported that TD 14-month-old infants were able to learn associations between novel words and objects rapidly, when tested using the infant habituation switch design. In this paradigm, infants were habituated to two nonsense word–object pairs (e.g., *dog*/*lif* and *truck/neem*), then tested with a familiar test (one of the habituation stimuli, e.g., *dog/lif*) and a *switch* test (a mismatched pairing of a habituated word and a habituated object, e.g., *dog/neem*). A novel test (e.g., *water wheel/pok*) was presented as a pre- and post-test stimulus. It was hypothesized that infants would detect the switch test, that is, they would longer looking at the switch test than at a familiar test, if they could form associations between words and objects rapidly. The novel test was used to control for infant fatigue.

Werker et al. (1998) found that 14-month-old infants looked longer at the switch test than at the familiar test, whereas 8-, 10-, and 12-month-old infants did not. They conducted a follow-up experiment to test whether the younger infants failed to detect the switch test because they could not process both the objects and/or words or because they struggled to form associations between them. In this follow-up task, Werker et al. habituated infants to one word–object pair and tested whether the infants could discriminate a familiar test trial from three novel test trials (i.e., novel object-familiar word, familiar object-novel word, and novel word-novel object test trials). Infants in the all three age groups, that is, 8-, 10, and 12-month-old infants, were able to detect the novel objects and words in the test trials. Although the follow-up discrimination experiment was simpler than the switch task, in that it involved only one word–object habituation stimulus rather than two, the results suggest that infants at the younger ages processed the word and object information, but did not form a link between them. Together these findings suggest that the ability to form associations between words and objects rapidly in this task, with these stimuli, is not present until 14 months.

Additional information suggests that 14-month-old infants can learn word–object associations under controlled laboratory tasks with a short period of repeated exposure, without referential cues (see Fennell & Waxman, 2010), and when phonetic details of words were *distinctive* (Pater, Stager, & Werker, 2004; Schafer & Plunkett, 1998; see review, Werker & Yeung, 2005; Stager & Werker, 1997; Werker et al., 1998; Woodward et al., 1994; Yoshida, Fennell, Swingley, & Werker, 2009). However, at 14 months, the ability to form word–object associations is still developing. Using the switch paradigm, Werker and colleagues have shown that 14-month-olds struggle to form word–object associations with phonetically *similar* words (i.e., *bih* and *dih*) (Stager & Werker, 1997; Werker et al., 2002). Werker et al. (2002) tested 14-, 17-, and 20-month-old infants. Fourteen-month-olds, who were found to learn word–object associations rapidly with phonetically *distinctive* words in the previous study (Werker et al., 1998), did not show evidence of forming word–object associations with phonetically *similar* words (Werker et al., 2002). Evidence for infants' ability to form associations between words and objects with phonetically similar words in the switch design was not found until 17 – 20 months of age (Werker et al., 2002). In a subsequent analysis, in which the researchers collapsed the data across age, infants with expressive vocabulary sizes of more than 25 words as well as infants with receptive vocabulary sizes of at least 200 words were found to learn word–object associations rapidly in the switch task. In contrast, infants with smaller expressive or receptive vocabulary sizes were not. Additionally, although 14-month-old infants on average did not detect the switch test, Werker et al. (2002) did find a significant correlation between switch difference score (i.e., difference in looking time between the familiar and the switch test trials) and expressive vocabulary size. Werker et al. (2002) interpreted these findings as evidence that infants with larger vocabulary sizes can more easily learn phonetically similar word–object pairs. This correlation is only strong in infants who are just beginning to build their vocabulary, as evidenced by the significant correlation in 14-, but not 17- and 20-month-olds.

Fourteen-month-old infants have shown the ability to form word–object associations with phonetically similar words but only when the task is made easier. For example, when phonetically similar *familiar* words (e.g., *ball* and *doll*) were used (Fennell & Werker, 2003), when only acoustic information was presented (Mani & Plunkett, 2007; Pater et al., 2004; Stager & Werker, 1997; Swingley & Aslin, 2002), when referential cues were added (Fennell & Waxman, 2010), and when infants were tested using a visual preference test with phonetically similar nonsense words (i.e., *bin* and *din*; Yoshida, Fennell, Swingley, & Werker, 2009), 14-month-old infants could form word–object associations with phonetically similar words. These findings suggest that it is plausible that 14-month-old infants can encode phonetic details and learn word–object pairs, but they cannot *consistently* detect the switch test stimulus as novel (Yoshida et al., 2009).

Collectively, these findings suggest that 12-month-olds are novice word learners and 14-month-olds are intermediate word learners. Unlike infants 12 months and younger (cf. MacKenzie, Curtin, & Graham, 2012), 14-month-olds are able to form word–object associations with phonetically distinctive words, however, they struggle to form associations between phonetically similar words and objects, which is unlike older, 17- and 20-month-olds.

Word–Object Associations in Infants and Toddlers with Williams Syndrome

The development of language acquisition is delayed in children with WS (Mervis, Robinson, Rowe, Becerra, & Klein-Tasman, 2003). In a study of 28 infants and toddlers with WS (Mervis, 2012), the expressive vocabulary size was measured using a newer version of the MacArthur Communicative Developmental Inventory (CDI; Fenson et al., 2007). Infants and toddlers with WS acquired 10 expressive words at the chronological age of 24.7 months (*SD* = 8.5, range = 15.6 – 53), which was comparable to the CDI 1st percentile. The CDI 50th percentile for 10 expressive words was 14 months. They acquired 50 expressive words at the chronological age of 32.1 months (*SD* = 11.4, range = 20.1 – 61.2), which was estimated to be less than the CDI 1th percentile. The CDI 50th percentile for 50 expressive words was 16 months. These infants and toddlers with WS acquired 100 expressive words at the chronological age of 34.3 months (*SD* = 12.5, range = 20.1 – 67.1). In TD infants, 100 expressive words were obtained at 18 months on average (Fenson et al., 2007).

Despite their delays in language acquisition, Mervis and John (2010) specified that children with WS have relative strengths in receptive and expressive concrete vocabulary (labels for objects or gestures), visual short-term memory, and grammatical abilities, but weaknesses in relational/conceptual language development and pragmatics. In a study of 92 5- to 7-year-olds with WS (Mervis & John, 2008), the mean *relative* vocabulary score measured by the Test of Relational Concepts (TRC; temporal, quantitative, dimensional, spatial, and other relational concepts, Edmonston & Litchfield Thane, 1998) was 55.79 (*SD* = 14.39, range = 44 – 112). However, the mean receptive *concrete* vocabulary score measured using the Peabody Picture Vocabulary Test (PPVT-III: Dunn & Dunn, 1997) was 86.73 (*SD* = 13.67, range = 59 – 118), which shows that concrete vocabulary, as compared to relational words, is a relative strength in children with WS. This study was replicated in an investigation of 129 4- to 17-year-olds with WS (Mervis & John, 2010) and was extended to include expressive concrete vocabulary. The standard scores on both the *receptive* vocabulary (*M* = 81.84) measured by the PPVT-4 (Dunn & Dunn, 2007) and the *expressive* vocabulary (*M* = 79.43) measured by the Expressive Vocabulary Test-2 (Williams, 2007) were in the low average range. By 4 years of age, children with WS score on average in the low average level.

Some have argued that the representation of word forms might be atypical in children with WS due to oversensitivity to acoustic information (Thomas et al., 2001). Some have also argued that phonological mechanisms in children with WS might not be typical due to atypical neurophysiological mechanisms (Bellugi, Poizner, & Klima, 1989). Finally, in addition, it has been argued that lexical acquisition in children with WS develops atypically (Nazzi & Karmiloff-Smith, 2002): 12 2- to 6-year-old children with WS (mean CA = 4.65 years) used physical appearance for object categorization, but could not successfully categorize objects based on the label alone. In an earlier study, it was found that 16-month-old TD infants could not categorize objects based on the label, but 20-month-old TD infants could categorize objects based on label alone as well as physical appearance alone (Nazzi & Gopnik, 2001). Based on the combined findings of the two aforementioned studies, it was concluded that the lexical acquisition of children with WS follows an atypical path, being mainly dependent on visual information instead of naming information, unlike 20-month-olds TD infants. However, it is also possible that children with WS might follow a similar developmental trajectory to that of TD infants, but they are delayed and in a similar developmental stage as 16-month-old TD infants.

Much of the research on early word learning in WS has demonstrated that they have language delays and has explored the content of their lexicon. Less research has focused on the early word learning mechanisms used by young children with WS. However, there is one very recent study that investigated word–object associations in children with WS. Havy, Moukawane, and Nazzi (2010) investigated whether 12 3- to 8-year-olds with WS (mean CA = 5 years 3 months) would process phonetic details while forming referential word–object associations. In this study, children with WS could learn word–object associations, and they showed a similar pattern in processing phonetic details to that of mental age matched TD controls. In the learning phase, participants were exposed briefly to two word–object pairs. Pseudo-words, which consisted of consonant contrasts (e.g., /vor/-/zor/) or vowel contrasts (e.g., /lud/-/lyd/), were paired with small novel objects. Within one trial, each object was named six times in short sentences by the experimenter. In the test phase, the experimenter presented a third novel object and named it one of the previously familiarized words. Then, participants were asked to find the familiarized object that was paired with the familiarized word. Performance on 16 trials by participants with WS was compared to that of 3 control groups: TD children of the same chronological age (CA; *n* = 12), non-verbal mental age (NVMA; mean NVMA = 3 years 10 months, *n* = 9), and verbal mental age (VMA; mean VMA = 4 years and 1 month, *n* = 9). When children with WS and CA controls were compared, the overall performance of children with WS was above chance, but was lower than that of CA controls. Although performance on learning consonant contrast-object associations was not different between children with WS and CA controls, children with WS showed lower performance on processing vowel contrast-object associations than CA controls. When children with WS and NVMA and VMA controls were compared, the overall performance, as well as performance patterns on phonetic contrasts, was not different among them. Children with WS and NVMA and MA controls were better at processing consonant contrasts than vowel contrasts. These findings show: (1) children with WS can form word–object associations, (2) the lower performance of children with WS than that of CA controls may be related to their intellectual functioning, and (3) children with WS and TD controls process phonetic details in the same manner. What is not known is how word–object associations are formed by children with WS, who are younger than 3 years of age.

In the present study, the main question was how infants and toddlers with WS initially learn words in the early years when their language development is delayed. In TD infants, forming links between words and objects is fundamental to word learning. However, whether infants and toddlers with WS, especially by 3 years of age, show a similar developmental pattern in learning to associate words and objects to that of TD infants has not yet been determined.

This investigation is the first study of whether infants and toddlers with WS, between 1 and 3 years of age, can learn word–object associations rapidly, and of how they process independent and associative information in words and objects. Findings from this study may elucidate our knowledge regarding the development of early word learning in very young children with WS.

The Present Study

The present study investigated word–object associations with phonetically *distinctive* words, not with phonetically similar words, for two reasons. First, the somewhat mixed findings regarding forming associations between phonetically similar words and objects (e.g., Fennell & Werker, 2003; Yoshida et al., 2009) suggest that the ability to form word–object associations is very task- or stimulus-dependent. Higher task demands hindered performance on the switch task (Werker et al., 2002), whereas, lower task demands or an easier task facilitated performance on the switch task (e.g., Fennell & Werker, 2003; Yoshida et al., 2009). In the previous study by Werker et al. (1998), the switch test was measured after being habituated with two word–object pairs, whereas the novel object and the novel word tests were measured after being habituated with one word–object pair, in a separate experiment. Also, the objects used in the Werker et al. (1998) study were dog and truck items, which would be familiar to infants.

To investigate developmental changes in word–object associations in TD infants, 12- and 14-month-old TD infants were tested using a within-subject design. The word–object switch task used in the present study included several modifications to the switch design used by Werker et al. (1998). The first modification was that the test phase included two additional test trials aimed at understanding whether participants processed the words and/or the objects. As illustrated in Figure 2, each participant was habituated to two word–object paired stimuli (e.g., *object A/neem,* and *object B/lif*) presented sequentially in a randomized order, and then tested with four test trials, presented semi-randomly (Latin square): (1) familiar, that is, one of the habituated word–object paired stimuli (e.g., *object A/neem)*, (2) switch, that is, a mismatched pairing of a familiar word and a familiar object (e.g., *object B/neem*), (3) novel word, that is, a familiar object paired with a novel word (e.g., *object B/pok*), and (4) novel object, that is, a familiar word paired with a novel object (e.g., *object C/lif*). The advantage of this within-subject design was that whether infants processed the objects, words, or word–object pairings could be determined in one experiment.

This study was also investigating the early word acquisition in young individuals with WS. No study to date has examined experimentally whether infants and toddlers with WS younger than 3 years of age can form word–object associations rapidly and also whether their development in this domain follows a trajectory similar to that of TD infants. Thus, the present study used the same word–object switch task with phonetically distinctive novel words and novel objects for both TD infants and infants and toddlers with WS.

Related to this issue, the second modification was made to accommodate testing infants and toddlers with WS in a habituation task. Few studies have been conducted (but see Cashon, Ha, DeNicola, & Mervis, 2013) in which a habituation task has been used to test individuals with WS. However, a pilot study using an earlier version of the word–object switch task indicated that infants and toddlers with WS needed more time to habituate than did TD infants. To resolve this issue, the maximum number of habituation trials was increased from 20 trials (the maximum in Werker et al., 1998) to 30 trials. Additionally, instead of using a habituation criterion window based on the first four trials, a sliding window of the six peak trials was used to determine whether a participant had habituated.

These modifications made it possible to test – in one experiment, instead of a series of experiments – whether non-verbal participants could form word–object associations, and also what information was being processed by those who could not yet form the associations. Using a within-subject design, such as this, was particularly important for testing infants and toddlers with WS. WS is a rare disorder, and those who participated came from all over the United States for brief visits. Thus, having an efficient way to test these participants was crucial.

The design of the present study allowed us to better assess the underlying mechanisms of early word learning. Werker et al. (1998) interpreted their findings as being consistent with Cohen's information-processing view of infant cognitive and perceptual development (Cohen, 1998; Cohen, Chaput, & Cashon, 2002; Cohen & Cashon, 2003, 2006). According to this view, infants initially process elements independently, and as they develop, they process the relations among those elements (Cohen & Cashon, 2001, 2003). Findings from Werker et al. (1998) suggest that in TD infants, the rapid learning of word–object associations follows a developmental progression from an independent to an integrated level of processing. Based on this information processing approach, in the present study, it is hypothesized that there would be two stages in the development of processing word–object associations: (1) processing the object and/or word information, but processing them independently of one another, and (2) processing the links between words and objects.

In the present study, processing the object information was determined by performance on the novel object test (i.e., looking longer at the novel object test than at the familiar test). Processing the word information was determined by performance on the novel word test (i.e., looking longer at the novel word test than at the familiar test). Associative processing of the word–object information was determined by performance on the switch test (i.e., looking longer at the switch test than at the familiar test). Because the switch test consists of a familiar word and a familiar object, and only a novel *combination* between those familiar stimuli, the switch test would not be novel to infants who processed only the words, only the objects or the words and objects independently. Additionally, because the process of habituation involves forming a memory and there was no delay between the habituation and test phase, a lack of longer looking at the switch test could not be due to a failure to retain associative information. Thus, if infants did not look longer at the switch test relative to the familiar test, it was interpreted as evidence that infants did not form word-object associations.

CHAPTER II

EXPERIMENT 1: WORD–OBJECT ASSOCIATIONS IN TYPICALLY DEVELOPING INFANTS

The aim of Experiment 1 was to investigate the developmental changes in the acquisition of word–object associations in 12- and 14-month-old TD infants. Findings from Experiment 1 were expected to provide insight into how learning of rapid word–object associations develops in TD infants – knowledge that would lay the groundwork for comparing word learning mechanisms used by TD infants to those used by infants and toddlers with WS.

There were two main hypotheses for the TD infants. First, based on the information processing approach, it was hypothesized that 12-month-old infants could process object and/or word information. However, 12-month-old infants were not expected to process associative information between words and objects. Second, in contrast, it was hypothesized that 14-month-olds could process object and word information as well as the associative information between words and objects.

Method

Participants

Twelve-month-old (11.5 to 12.5 months) and 14-month-old (13.5 to 14.5 month) full-term, healthy, and monolingual TD infants with normal or corrected-to-normal vision and hearing were recruited in this study. Participants were recruited through a list of infants born in the metropolitan Louisville area provided by the Kentucky Cabinet for Health and Family Services birth records department. This list consisted of the infants' names, birthdays, genders, and parents' names and addresses. Phone numbers were obtained from public information on the Internet. Parents and infants were invited to participate by letter followed by a phone call. Also TD siblings of children with WS or 7q11.23 duplication syndrome, who were participating in a larger study in another lab in the same department, were invited to participate in the present study during their visits. Participants received a small gift, such as a t-shirt or a bib, for participating. Only infants who successfully completed the word–object switch task and whose parents had completed the vocabulary measure were included in the final dataset.

Twenty-two 12-month-olds infants (12 girls and 10 boys, M age = 12.02 months, SD = .27, age range = 11.70 – 12.48) were included in the final dataset. An additional 10 12-month-olds were tested, but they were excluded for the following reasons: (1) not meeting the habituation criterion (i.e., mean looking times during the last 6 habituation trials were not less than 50% of the mean looking times during the peak 6 habituation trials, $n = 2$), (2) not being fully habituated (i.e., looking time on the familiar test trial was over 2 standard deviations above the mean, $n = 1$), (3) fussiness ($n = 1$), (4) family interference ($n = 2$), (5) incomplete vocabulary measure ($n = 2$), (6) bilingual ($n = 1$), and (7) experimenter error (i.e., there was greater than a one-second difference in looking time on any of the test trials recorded online by the first experimenter and offline by the second experimenter, $n = 1$). Additionally, to ensure that infants had a chance to encode the word information in each of the test trials, individual test trials were excluded if infants turned away prior to when the first word of any of the four test trials was played (see Appendix A1). In the final dataset for the younger age group, one novel word test trial was excluded because of an infant's turning away before the word was presented (turning away at 1.1 sec before 1.37 sec, the average presentation delay of 6 word stimuli).

In the older age group, the final dataset consisted of eighteen 14-month-olds (9 girls and 9 boys, *M* age = 14.04 months, *SD* = .29, age range = 13.50 – 14.49). Data from eight additional 14-month-olds were excluded because of: (1) not being fully habituated (*n* = 1), (2) fussiness (*n* = 3), (3) family interference (*n* = 1), and (4) incomplete vocabulary measure (*n* = 3). Additionally, three novel word test trials were excluded (see Appendix A2) because of infants' turning away before the word was initially presented (turning away at 1.3 sec before 1.37 sec, the average presentation delay of 6 word stimuli, *n* = 1; turning at 1.2 sec before 1.37 sec, the average presentation delay of 6 word stimuli, *n* = 2).

Stimuli

The complete set of stimuli consists of 16 digital movies of unfamiliar objects moving horizontally across the screen paired with nonsense words spoken by a female using infant-directed speech. These 16 movies consisted of 2 sets of 8 movies, with each set including phonetically distinct words and objects that were easily distinguishable (see Figure 1; see Appendix B for details).

The objects were created by modifying pictures of unusual toys or shapes, obtained from the NOUN Database (obtained from Jessica Horst) or the Internet, in Adobe® Photoshop®. The objects measured between 14 - 26 cm in height (visual angle: 11.4º-17.1º) and 12 - 26 cm in width (visual angle: 6.5º-13.4º). The objects moved back and forth horizontally repeatedly across the screen in a range of 27 cm. Left-to-right motions were made using Adobe® After Effects®.

The nonsense words consisted of consonant-vowel-consonant (CVC) combinations. In each movie, a nonsense word played repeatedly throughout the trial with some variation of vocal pitch. In each movie, the word stimuli were presented 9 times in 20 sec. Each movie began with an average of 1.37 sec of silence, followed by the presentation of the word, which lasted an average of .9 seconds in duration. This cycle was repeated until the trial ended. These nonsense words were either obtained from Werker et al. (1998)'s study, or recorded by a female, native English speaker using a microphone, and were added to the movies using QuickTime Pro.

Apparatus

Stimuli were presented to participants on a Panasonic 50" color plasma display (45 X 26 inches with 1024 X 576 resolutions). The volume was set to level 23 on the monitor across all participants. An experimenter controlled the stimulus presentation and recorded looking times using Habit X software (Cohen, Atkinson, & Chaput, 2004) running on a Power Mac G5 computer. The experimenter viewed participants on a 15" JVC color monitor that was connected to a Canon VC-C50i camera hidden below the plasma display. Sessions were recorded to a DVD in order to test for reliability off-line at a later time. To avoid experimenter bias, the experimenter was blind to the habituation and test stimuli, test order, and shifts from the habituation phase to the test phase during the experimental session. Data from all participants were tested for inter-rater reliability. To compute inter-rater reliability, a second trained experimenter ran Habit X while viewing the DVD of each testing session. If there was a difference greater than 1s on any of the test trials, that participant was excluded. The correlation between the looking times recorded by the live experimenter and the offline experimenter was $r = .99$.

Procedure

Each infant was seated on a parent's or an experiment assistant's lap approximately 120 cm away from the presentation monitor in a dimly lit experiment room. To minimize distractions, the parent or assistant was instructed not to interact with the infant during testing. At the beginning of the experimental session, and before each trial throughout the experiment, a digital movie (attention-getter) of an expanding and contracting green ball on a black background accompanied by a "dinging" sound played in the center of the monitor to attract the infant's attention to the center of the screen. When the infant's attention was directed at the attention-getter, the experimenter pressed the "Enter" key to start the trial. During each trial, the experimenter held down the "5" key while the infant was looking at a stimulus and released it when the infant looked away. Each trial ended when an infant looked away from a stimulus for at least 1 second or until the maximum looking time per trial (20 seconds) had elapsed.

Each infant was randomly assigned to one of two stimulus sets and presented with two habituation stimuli and four test stimuli (see Figure 2). During the habituation phase, each infant viewed two word–object paired stimuli (e.g., *object A/neem* and *object B/lif*) presented on separate trials in a quasi-random order. The habituation phase continued until the habituation criterion had been met, i.e., the mean looking time during 6 consecutive trials had decreased by 50% or more from the mean looking time of the 6 consecutive trials with the longest total looking time (peak habituation trials). If an infant did not meet the habituation criterion in 30 trials (the maximum number of habituation trials), the test phase began, but the data of this infant were excluded from the data analyses.

During the test phase, a total of four test stimuli were presented randomly following a Latin-square design: familiar (one of the habituation stimuli, e.g., *object A/ neem*), switch (a novel pairing of a familiar word and a familiar object, e.g., *object A/lif* or *object B/neem*), novel word (a novel word paired with a familiar object, e.g., *object A/pok,* or *object B/pok*) and novel object (a familiar word paired with a novel object, e.g., *object C/neem,* or *object C/lif*).

Vocabulary measure

Before or after the word–object task, parents were asked to fill out the MacArthur Communicative Developmental Inventory: Word and Gestures (CDI: WG; Fenson et al., 2007). Parents were asked to report whether their children understand [U], say [S], use manual signs [M], or both say and use manual signs [B] for the 396 words included in the vocabulary checklist section of the CDI: WG. Receptive vocabulary size (RV) was scored by summing the total number of words marked in any of the four vocabulary categories described above (i.e., U, S, M, and B). Expressive vocabulary (EV) was scored by summing the total number of words reported as S, M, or B for each child.

Results

Due to the uneven sample sizes in the test trials and non-normality in the 12- and 14-month-old groups, nonparametric tests were conducted in the following data analyses.

Habituation Phase

To examine whether there were any differences between 12- and 14-month-old infants during the habituation phase, separate Mann-Whitney U tests were conducted on the number of trials to reach the habituation criterion, peak six habituation trials, and last six habituation trials between age. No significant differences were found in any of the analyses. No significant difference was found in the number of trials to reach habituation criterion between the younger (*Mdn* = 15.0) and older (*Mdn* = 14.0) groups, $U = 195.0$, $z = -.08$, $p = .94$. Similarly, no significant difference in median looking time for the peak six habituation trials was found between 12-month-olds (*Mdn* = 12.4) and 14-month-olds (*Mdn* = 15.2), $U = 145.0$, $z = -1.44$, $p = .15$. Finally, no significant difference in median looking time for the last six habituation trials was found between 12-month-olds (*Mdn* = 5.7) and 14-month-olds (*Mdn* = 6.9), $U = 144.5$, $z = -1.46$, $p = .15$.

Test Phase

To determine how the 12- and 14-month-olds processed the words, objects, and word–object pairings, average looking times during the four test trials (familiar, switch, novel word, novel object) were analyzed separately for each age group (see Figure 3a and 3b). In each age group, first a main effect for test trials was tested with a Friedman test. Wilcoxon tests were used for follow-up planned comparisons to compare the switch, novel word, and novel object test trials each to the baseline, familiar test trial within each age group.

In 12-month-old infants, a significant main effect for test trials was found, χ^2 (3) = 17.79, $p < .0001$. Planned comparisons revealed no significant difference in looking times between the familiar and switch tests, $z = -.81$, $p = .417$, indicating that these younger infants on average did not form associations between the words and objects they saw and heard repeatedly during the habituation phase. Planned comparisons did, however, reveal significantly longer looking time for the novel object test compared to the familiar test, $z = -3.70$, $p < .0001$. A difference in looking time between the familiar and the novel word tests was not found to be significant, $z = -1.72$, $p = .086$. These results indicate that the 12-month-olds predominantly processed the object information in the stimuli.

For 14-month-old infants, a significant main effect for test trials was found, χ^2 (3) = 15.85, $p = .0001$. However, the planned comparisons revealed a different pattern of looking from that of the 12-month-olds. Unlike the 12-month-old infants, a significant difference was found in all three comparisons. Compared to the familiar test, the 14-month-olds looked significantly longer at the switch test, $z = -3.03$, $p = .002$, the novel object test, $z = -3.72$, $p < .0001$, and the novel word test, $z = -2.07$, $p = .038$, indicating that these older infants processed the words, objects, and word–object pairings.

The number of infants who looked longer at each novel test trial compared to the familiar test trial (e.g., switch – familiar > 0). For the younger age group, 14 of 22 (64%) of these infants looked longer at the switch test than at the familiar test; 19 of 22 infants (86%) looked longer at the novel object test than at the familiar test; and 14 of 21 (67%) younger infants looked longer at the novel word test than at the familiar test.

In the 14-month-old group, however, 14 of 18 infants (78%) looked longer at the switch test than at the familiar test; 100% of the infants looked longer at the novel object test than at the familiar test; and 11 of 15 infants (73%) looked longer at the novel word test than at the familiar test.

Vocabulary size. Receptive and expressive vocabulary sizes for the 12- and 14-month-old infants are presented in Table 1.

Discussion

The findings in Experiment 1 show a developmental difference in the ability to form word–object associations between 12 and 14 months of age in TD infants. As expected, 14-month-old infants evidenced the ability to form word–object associations by looking longer at the switch test than at the familiar test, but 12-month-olds did not. In fact, 12-month-old infants were found to predominantly process the objects as evidenced by their significantly longer looking only at the novel object test compared to the familiar test. The difference between the novel word test and the familiar test was only marginally significant at this younger age. In contrast, 14-month-old infants looked longer at the switch test than at the familiar test, as well as at the novel object test and at the novel word test. Thus, these findings show that in this word–object switch task, 14-month-old infants processed words, objects, and associations between words and objects, whereas 12-month-olds processed predominantly to the change in objects. Between 12 and 14 months of age, there is a developmental progression from processing the independent features of the input, in this case predominantly the objects, to forming associations between words and objects paired together.

Methodologically, the modified word–object switch task used in this study was found to be an effective and sensitive well-controlled measure to study the development of word learning in TD infants. Using this mechanistic approach to studying word learning in TD infants helps lay the groundwork for studying how words are acquired in those who are delayed in their language acquisition, such as young children with WS. In the subsequent experiment (Experiment 2), this study was replicated in a sample of infants and toddlers with WS aged 1-3 years old.

CHAPTER III

EXPERIMENT II: WORD–OBJECT ASSOCIATIONS IN INFANTS AND TODDLERS WITH WILLIAMS SYNDROME

To investigate the ability of infants and toddlers with WS to acquire word–object associations rapidly, the same modified version of the word–object switch task used in Experiment 1 with TD infants was used in Experiment 2. In this experiment, infants and toddlers with WS, all who were between 1 and 3 years of age, were tested. Although it is delayed, the language development of infants and toddlers with WS may follow a similar developmental pattern to that of TD infants. Similar to the hypotheses posed in the study of TD infants in Experiment 1, there are two main hypotheses for toddlers with WS. First, based on the information processing approach, it was hypothesized that younger infants and toddlers with WS would mainly process the word and/or object information independently and would struggle to process the associations between words and objects. Second, it was hypothesized that older toddlers with WS would successfully process associative information between words and objects.

Method

The stimuli, apparatus, and procedure were identical to those of Experiment 1.

Participants

Infants and toddlers with a genetically confirmed diagnosis of WS between the ages of 1 and 3 were eligible to participate in this study. Participants were grouped in two age ranges, 1 – 1.99 and 2 – 2.99 years of age. Classic-length deletions determined by

FISH or qPCR, and normal or corrected-to-normal vision and hearing were required. These participants were recruited from around the United States to participate in a larger study in another lab in the same department and invited to participate in the present study during their visit. Participants received a small gift, such as a t-shirt or a bib, for participating. As in Experiment 1, only infants who successfully completed the word–object switch task and whose parents had completed the vocabulary measure were included in the final dataset. Additionally, to ensure that infants had a chance to encode the word information in each of the test trials, individual test trials were excluded if infants turned away prior to when the first word of any of the four test trials was played (see Appendices B3 and B4). Data from 100% of the participants were tested for inter-rater reliability (see details in Experiment 1). The correlation between the looking times recorded by the live experimenter and the offline experimenter was $r = .98$.

In the younger age group, the final dataset consisted of 16 (8 girls and 8 boys) 1- to 1.99-year-old infants and toddler with WS. Mean adjusted chronological age was 1.51 years ($SD = .26$, age range = 1.06 – 1.87), with adjustments for four premature participants. An additional one 1- to 1.99-year-old with WS was tested, but excluded for fussiness ($n = 1$). In the final dataset for this younger age group with WS, one novel word test trial was excluded because of an infant's turning away before the word was presented (turning away at 1.1 sec before 1.37 sec, the average presentation delay of 6 word stimuli).

In the older age group, the final dataset consisted of 17 (7 girls and 10 boys) 2- to 2.99-year-old toddlers with WS. Mean adjusted chronological age was 2.48 years ($SD = .29$, age range = 2.03 – 2.95), with an adjustment for one premature participant. An additional eleven infants and toddlers with WS were tested, but they were excluded for the following reasons: (1) not meeting the habituation criterion (n = 1), (2) not fully habituating, (n = 2), (3) fussiness (n = 6), (4) family interference (n = 1), and (5) experimental error (n = 1).

Developmental Assessment. The intellectual functioning of infants and toddlers with WS in the present study was measured using the Mullen Scales of Early Learning (MSEL; Mullen, 1995), a standardized measure of early cognitive and motor development. The MSEL provides the Early Learning Composite (ELC), which corresponds to Developmental Quotient. All 33 participants with WS completed the MSEL.

In the younger age group with WS, 12 of 16 participants completed the MSEL within 1 day of the test date for the word–object switch task. The remaining 4 participants completed the MSEL at a different time, ranging from approximately 2 months prior to 2 months after being tested in this study (mean difference: 1.5 months). ELCs of this younger age group ranged from 51 (moderate developmental delay) to 100 (average for the general population), with a mean of 70 (mild developmental delay; SD = 15.45).

In the older age group with WS, 12 of 17 participants completed the MSEL within 1 day of the test date for the word–object switch task. The remaining 5 participants completed the MSEL at a different time, ranging from approximately 1 to 5 months prior (mean difference: -3.4 months). ELCs of this older age group ranged from 49 (moderate developmental delay) to 93 (average for the general population), with a mean of 65 (mild developmental delay; SD = 15.93).

For both age groups combined in the present study, the mean ELC was 68 (SD = 15.7), which is similar to the mean ELC (61.45) reported by Mervis and John (2010) for a sample of 144 toddlers and preschoolers (aged 2.01 – 4.96 years) with WS. Therefore, the intellectual functioning of the participants in the present study relative to individuals their age in the general population is consistent with that which is expected for very young children with WS.

Results

Due to non-normality of the two age groups with WS and to be consistent with the analyses run in Experiment 1, similar nonparametric tests were conducted in the following data analyses.

Habituation Phase

To examine whether there were any differences between 1- to 1.99-year-olds with WS and 2- to 2.99-year-olds with WS during the habituation phase, Mann-Whitney U tests were conducted. No significant difference was found in the number of trials to reach habituation criterion between the younger age group with WS (Mdn = 18.0) and the older age group with WS (Mdn = 16.0), U = 118.0, z = -.65, p = .51. A difference in median looking time for the peak six habituation trials between the younger group (Mdn = 17.2) and older group (Mdn = 13.6), was almost significant, U = 84.0, z = -1.87, p = .061. Finally, there was a significant difference in median looking time on the last six habituation trials between 1- to 1.99-year-olds with WS (Mdn = 7.5) and 2- to 2.99-year-olds with WS (Mdn = 5.9), U =69.0, z = -2.41, p = .016. These findings show that whereas there is no difference in the number of trials to reach habituation criterion, the older toddlers with WS were looking slightly less at the end of the habituation phase.

Test Phase

To investigate how the 1- to 1.99-year-olds with WS and 2- to 2.99-year-olds with WS processed the word–object pairings, analyses similar to those in Experiment 1 were conducted for each age group (see Figures 4a and 4b).

In the younger age group with WS, a significant main effect for test trials was found, χ^2 (3) = 17.76, p = .001. As hypothesized, planned comparisons revealed no significant difference in looking time between the familiar and switch tests, z = -.93, p = .35. However, they did indicate that these younger infants and toddlers with WS looked significantly longer at the novel object test, z = -3.53, p < .0001, and the novel word test, z = -2.64, p = .008, compared to the familiar test.

For the older age group with WS, again, a significant main effect for test trials was found, χ^2 (3) = 15.55, p = .001. However, as predicted, planned comparisons revealed a different pattern of looking from that of the younger age group with WS. Unlike the younger infants and toddlers with WS, the older toddlers with WS looked significantly longer at the switch test compared to the familiar test, z = -2.23, p = .022. Additionally, these older toddlers with WS also looked significantly longer at the novel object test, z = -3.53, p < .0001, and the novel word test, z = -2.84, p = .005, compared to the familiar test.

In the younger WS age group, 9 of 16 participants (56%) looked longer at the switch test than at the familiar test; 15 of 16 participants (94%) looked longer at the novel object test than at the familiar test; and, 11 of 15 participants (73%) looked longer at the novel word test than at the familiar test.

In the older WS age group, 16 of 17 participants (94%) looked longer at the novel object test than at the familiar test; 12 of 17 participants (71%) looked longer at the novel word test than at the familiar test; and 12 of 17 participants (71%) looked longer at the switch test than at the familiar test.

***Vocabulary size*.** Receptive and expressive vocabulary sizes for the younger and older participants with WS are presented in Table 2.

Discussion

The findings in Experiment 2 show a developmental change in the acquisition of word–object associations in infants and toddlers with WS between 1 and 3 years of age. As expected, 1- to 1.99-year-olds with WS looked longer at the novel object test and at the novel word test than at the familiar test, but they did not look longer at the switch test than at the familiar test. In contrast, 2- to 2.99-year-olds with WS looked longer at all three novel tests compared to the familiar test. Thus, as hypothesized, a developmental change from an independent to an integrated level of processing in learning word–object associations was evidenced in infants and toddlers with WS between 1-3 years of age. These results indicate that toddlers with WS develop the ability to rapidly learn word–object associations as early as 2 years of age, which is younger than previously found (Havy, Moukawane, & Nazzi, 2010; their study included 3- to 8-year-olds).

The main developmental pattern found in this experiment with the participants with WS was very similar to that found with TD infants in Experiment 1. This suggests that although their language development is delayed, infants and toddlers with WS go through certain, similar developmental changes in language acquisition as infants in the TD population.

CHAPTER IV

GENERAL DISCUSSION

The findings in Experiment 1 indicated that there is a developmental change in learning to associate words and objects rapidly between 12 and 14 months in TD infants. While 12-month-old TD infants mainly processed objects, 14-month-old TD infants processed associative information between words and objects. Similarly, the findings in Experiment 2 indicated that there is a developmental change in learning to associate words and objects rapidly in infants and toddlers with WS. Whereas 1-year-olds with WS processed both words and objects, they struggled to form associations between them; 2-year-olds with WS, however, processed associative information between words and objects. These results supported our hypothesis that by 2 years of age, infants and toddlers with WS are becoming more efficient in word learning. The emergence of associative processing of word–object information found in the older age groups in this study may show that their word acquisition ability has transitioned into an associative mode, which facilitates a shift to a referential mode, that is, mapping words to concepts, after the vocabulary spurt (Nazzi & Bertoncini, 2003; Werker et al., 1998).

The findings in the present study provided evidence of underlying mechanisms of early word learning in both TD infants and infants and toddlers with WS. In the present study on learning word–object associations, a domain-general developmental progression from an independent to an integrated level of processing was found (Cohen, 1998; Cohen & Cashon, 2003; Cohen, Chaput, & Cashon, 2003). In both TD infants and infants and toddlers with WS, novice word learners, who were in the independent processing phase, mainly processed the word and/or object information, but struggled to rapidly form word–object associations. In contrast, intermediate word learners processed words, objects, and associative information between words and objects. This developmental progression was consistent with Cohen's information processing approach to infant cognitive and perceptual development.

When the results across both experiments were considered, the findings suggested that the development of the ability to form word–object associations may progress in three stages: (1) processing the object, (2) processing the word and the object, but not the association between them, and (3) the emergence of rapid associative processing of word–object information. On average, the younger TD participants' behavior was consistent with the 1st stage (i.e., processing to the objects) and may have been on the cusp of the 2nd stage (i.e., processing the word information as well). The behavior of the young individuals with WS was consistent with the 2nd stage of the developmental progression. The behaviors of the TD 14-month-old infants and the older toddlers with WS were consistent with the 3rd stage of the developmental progression.

It is possible that the difference between stages 1 and 2 stems from perceptual properties of the objects and words. Although the objects and words were both presented in every trial, there were some differences between them that may make the objects more salient. The words were spoken in infant-directed speech (Thiessen & Saffran, 2005), however, there were delays between when each word is presented. In contrast, the objects had vivid colors and are in constant motion on the screen. The evidence was clear that older TD infants and older infants and toddlers with WS still processed both the words, objects, and the associations between them, however, it is unclear whether these perceptual differences between the objects and words may play a role in the younger TD infants' responses to the stimuli. Regarding the stimulus presentation, a lack of temporal synchrony (i.e., presentation of words perfectly coinciding with object motion) might hinder processing of word information in the younger TD infants. It has been shown that amodal information (i.e., redundant information across sensory modalities) such as temporal synchrony constrains early intermodal learning including speech-object associations, and this constraint decreases with age (Gogate & Bahrick, 1998; Gogate, Prince, Matayaho, 2009; see review, Bahrick & Lickliter, 2012; Slater, Quinn, Brown, & Hayes, 1999; Werker et al., 1998).

Future studies should address the validity and reliability of the 3-stage developmental progression. In TD infants, it was not determined whether and when infants would show a progression to the 2nd stage. Thus, future research should investigate the rapid learning of word–object associations in 13-month-old infants, who are between the 12- and 14-month-olds in the present study, to help delineate the developmental trajectory in early word learning in TD infants. Similarly, to further investigate the developmental progression in infants and toddlers with WS, and specifically investigate the existence of the 1st stage, a sample of infants with WS younger than 1-year of age should be tested.

To clarify whether temporal asynchrony may have led the younger TD infants to focus predominantly on the objects, future research should replicate this study with temporal synchrony, such as presenting the objects only when the words are heard. If 12-month-old TD infants could process word information with temporal synchrony, it would show that word information is more constrained by intersensory redundancy compared to object information, and it would provide further evidence for a three-stage model of development of word–object associations.

To improve our understanding of early word learning in young children with WS, future research also should investigate the next milestone in early word learning: mapping phonetically similar words onto objects (e.g., Werker et al., 2002; Yoshida et al., 2009). Havy et al. (2010) studied the fast mapping abilities of 3- to 8-year-olds with WS with phonetically similar words. However, to my knowledge, no study has investigated whether children with WS younger than 3 years have the ability to form phonetically similar word–object associations using the switch task. This investigation would give us a better understanding of the mechanisms underlying the developmental trajectory of early word learning in young children with WS.

While people with WS are very interested in people, their communicative skills do not develop in a typical manner in children with WS aged 3 to 6 years (Thurman & Mervis, 2013). These socio-communicative deficits may contribute to their delay in language learning. In the TD population, a developmental shift from relying on associative cues to social cues for word learning was found (Golinkoff & Hirsh-Pasek, 2006; Hennon, Chung, & Brown, 2000; Pruden et al. 2006), and it has been suggested that a delayed shift from relying on associative cues to social cues may explain the language delay in populations with less social referential sensitivity (Pruden et al. 2006). It has been reported that referential cues and social cues improves performance on word learning tasks, including the switch task in the TD population (e.g., Briganti & Cohen, 2011; Fennell & Waxman, 2010). Only one study to my knowledge has investigated the role of referential cues in fast mapping in young children with WS, however, again it included children over 3 years of age (Havy et al., 2010). It could be very informative to compare TD infants and infants and toddlers with WS on the word–object switch task when referential cues and social interactions are added.

In sum, the developmental changes found in the acquisition of word–object associations in the present study add important knowledge about the early language acquisition in TD infants and infants and toddlers with WS to the literature. The current work gives us insight into the underlying mechanisms involved in early word learning in the TD population, and especially, in infants and toddlers with WS. The current findings shed light on how this very young population with WS processes linguistic information while their language development is delayed. Moreover, the findings suggest that at least some of the processes involved in early word learning are quite similar between TD infants and infants and toddlers with WS. These two experiments illustrate how the information processing approach can be a useful framework for studying and understanding early word learning skills in young individuals with and without WS.

REFERENCES

Bahrick, L.E., & Lickliter, R. (2012). The role of intersensory redundancy in early perceptual, cognitive, and social development. In A. Bremner, D. J. Lewkowicz, & C. Spence (Eds.), *Multisensory development* (pp. 183-205). Oxford University Press: Oxford, England.

Bellugi, U., Poizner, H., & Klima, E. S. (1989). Language, modality and the brain. *Trends in Neurosciences*, *12*(10), 380-388. doi: 10.1016/0166-2236(89)90076-3

Benedict, H. (1979). Early lexical development: comprehension and production. *Journal of Child Language*, *6*(2), 183-200. Retrieved from [http://www.ncbi.nlm.nih.gov/pubmed/468932]

Briganti, A. M., & Cohen, L. B. (2011). Examining the role of social cues in early word learning. *Infant Behavior and Development*, *34*(1), 211-214. doi: 10.1016/j.infbeh.2010.12.012

Cashon, C. H., Ha, O. R., DeNicola, C. A., & Mervis, C. B. (2013). Toddlers with Williams Syndrome process upright but not inverted faces holistically. *Journal of Autism and Developmental Disorders*, 1-9. doi: 10.1007/s10803-013-1804-0

Cohen, L. B. (1998). *An information-processing approach to infant perception and cognition.* In F. Simion & G. Butterworth (Eds.), The development of sensory, motor, and cognitive capacities in early infancy (pp. 277-300). East Sussex: Psychology Press.

Cohen, L. B., Atkinson, D. J., & Chaput, H. H. (2004). *Habit X: A new program for obtaining and organizing data in infant perception and cognition studies (Version 1.0)*. Austin: University of Texas.

Cohen, L. B., & Cashon, C. H. (2001). Infant object segregation implies information integration. *Journal of experimental child psychology*, *78*(1), 75–83; discussion 98–106. doi:10.1006/jecp.2000.2602

Cohen, L. B., & Cashon, C. H. (2003). *Infant perception and cognition*. In J. Mistry, R. Lerner, & M. A. Easterbrookds (Eds.), Handbook of psychology: Developmental psychology (Vol. 6, pp. 65-89). NJ: John Wiley & Sons.

Cohen, L. B., & Cashon, C. H. (2006). *Infant Cognition*. In W. Damon, R. M. Lerner, D. Kuhn, & R. S. Siegler (eds.), Handbook of child psychology: Volume 2, Cognition, perception and language (6th ed., pp. 214-251). Hoboken, NJ: John Wiley and Sons.

Cohen, L. B., Chaput, H. H., & Cashon, C. H. (2002). A constructivist model of infant cognition. *Cognitive Development*, *17*, 1323-1343. doi: 10.1016/S0885-2014(02)00124-7

Dunn, L. E., & Dunn, L. E. (1997). *Peabody Picture Vocabulary Test–3rd edition*. Circle Pines, MN: American Guidance Service.

Dunn, L. M., & Dunn, D. M. (2007). *Peabody Picture Vocabulary Test–4th edition*. Minneapolis, MN: Pearson Assessments.

Edmonston, N.K., & Litchfield Thane, N. (1988). *TRC:Test of Relational Concepts.* Austin, TX:PRO-ED.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*, 175-191. doi: 10.3758/BF03193146

Fennell, C. T., & Waxman, S. R. (2010). What paradox? Referential cues allow for infant use of phonetic detail in word learning. *Child Development*, *81*(5), 1376-1383. doi: 10.1111/j.1467-8624.2010.01479.x

Fennell, C. T., & Werker, J. F. (2003). Early word learners' ability to access phonetic detail in well-known words. *Language and Speech*, *46*(2-3), 245-264. doi: 10.1177/00238309030460020901

Fenson, L., Marchman, V. A., Thal, D., Dale, P. S., Bates, E. & Reznick, J. S. (2007). *The MacArthur-Bates Communicative Development Inventories user's guide and technical manual, 2nd ed*. Baltimore, MD: Brookes.

Fernald, A., Pinto, J. P., Swingley, D., Weinbergy, A., & McRoberts, G. W. (1998). Rapid gains in speed of verbal processing by infants in the 2nd year.*Psychological Science*, *9*(3), 228-231. doi: 10.1111/1467-9280.00044

Gogate, L. J., & Bahrick, L. E. (1998). Intersensory redundancy facilitates learning of arbitrary relations between vowel sounds and objects in seven-month-old infants. *Journal of experimental child psychology*, *69*(2), 133-149. doi: 10.1006/jecp.1998.2438

Gogate, L. J., Prince, C. G., & Matatyaho, D. J. (2009). Two-month-old infants' sensitivity to changes in arbitrary syllable–object pairings: The role of temporal synchrony. *Journal of Experimental Psychology: Human Perception and Performance*, *35*(2), 508. doi: 10.1037/a0013623

Goldfield, B. A., & Reznick, J. S. (1990). Early lexical acquisition: Rate, content, and the vocabulary spurt. *Journal of child language*, *17*(1), 171-183. doi: 10.1017/S0305000900013167

Golinkoff, R. M., & Hirsh-Pasek, K. (2006). Baby wordsmith from associationist to social sophisticate. *Current directions in psychological science*, *15*(1), 30-33. doi: 10.1111/j.0963-7214.2006.00401.x

Gopnik, A., & Meltzoff, A. (1987). The development of categorization in the second year and its relation to other cognitive and linguistic developments. *Child development*, 1523-1531. [http://www.jstor.org/stable/1130692]

Havy, M., Moukawane, S., & Nazzi, T. (2010). Are 3-to-8-year-old children with Williams syndrome good word-learners? *NeuroReport*, *21*(13), 882-886. doi: 10.1097/WNR.0b013e32833da451

Hillier, L.W., Fulton, R.S., Fulton, L.A., Graves, T.A., Pepin, K. H., Wagner-McPherson C. et al. (2003). The DNA sequence of human chromosome 7. *Nature, 424*, 157-164. doi: 10.1038/nature03

Hennon, E., Chung, H. L. & Brown, E. (2000), V. What does it take for 12-month-olds to learn a word? *Monographs of the Society for Research in Child Development, 65*, 3, 62–84. doi: 10.1111/1540-5834.00095

Howlin, P., Davies, M., & Udwin, O. (1998). Cognitive functioning in adults with Williams syndrome. *Journal of Child Psychology and psychiatry*, *39*(2), 183-189. doi:10.1017/S0021963097001789

Howlin, P., Elison, S., Udwin, O., & Stinton, C. (2010). Cognitive, linguistic and adaptive functioning in Williams syndrome: Trajectories from early to middle adulthood. *Journal of Applied Research in Intellectual Disabilities*, *23*(4), 322-336. doi:10.1111/j.1468-3148.2009.00536.x

MacKenzie, H., Curtin, S., & Graham, S. A. (2012). 12-Month-Olds' Phonotactic Knowledge Guides Their Word–Object Mappings. *Child development*, *83*(4), 1129-1136. doi: 10.1111/j.1467-8624.2012.01764.x

Mani, N., & Plunkett, K. (2007). Phonological specificity of vowels and consonants in early lexical representations. *Journal of Memory and Language*, *57*(2), 252-272. doi: 10.1016/j.jml.2007.03.005

Marcus, G. F., Fernandes, K. J., & Johnson, S. P. (2012). The role of association in early word-learning. *Frontiers in Psychology*, *3*. doi: 10.3389/fpsyg.2012.00283

Mervis, C. B. (July, 2012). *Language development of children with Williams syndrome: Variability, concurrent correlations and predictive relations*. Presented at the Williams Syndrome Association International Professional Meeting, Boston, MA.

Mervis, C. B., & John, A. E. (2008). Vocabulary abilities of children with Williams syndrome: Strengths, weaknesses, and relation to visuospatial construction ability. *Journal of Speech, Language, and Hearing Research*, *51*, 967-982. doi:10.1044/1092-4388(2008/071)

Mervis, C. B., & John, A. E. (2010). Cognitive and behavioral characteristics of children with WS: Implications for intervention approaches. *American Journal of Medical Genetics Part C Seminars in Medical Genetics*, *154C*, 229-248. doi:10.1002/ajmg.c.30263

Mervis, C. B., & John, A. E. (2012). *Precursors to language and early language development in Williams syndrome*. In E. K. Farran & A. Karmiloff-Smith (Eds.), Neurodevelopmental disorders across the lifespan: A neuroconstructivist approach (pp. 187-204). Oxford, UK: Oxford University Press.

Mervis, C. B., Robinson, B. F., Bertrand, J., Morris, C. A., Klein-Tasman, B. P., & Armstrong, S. C. (2000). The Williams syndrome cognitive profile. *Brain and Cognition, 44*, 604-628. doi:10.1006/brcg.2000.1232

Mervis, C. B., Robinson, B. F., Rowe, M. L., Becerra, A. M. & Klein-Tasman, B. P. (2003). Language abilities of individuals who have Williams syndrome. In L. Abbeduto (Ed.), *International Review of Research in Mental Retardation* (vol. 27, pp. 35-81). Orlando, FL: Academic Press.

Mullen, E. M. (1995). *Mullen Scales of Early Learning*. Circle Pines, MN: American Guidance Service.

Nazzi, T., & Bertoncini, J. (2003). Before and after the vocabulary spurt: two modes of word acquisition?. *Developmental Science*, *6*(2), 136-142. doi: 10.1111/1467-7687.00263

Nazzi, T., & Gopnik, A. (2001). Linguistic and cognitive abilities in infancy: when does language become a tool for cognition? *Cognition*, *80*, B11-20. doi:10.1016/S0010-0277(01)00112-3

Nazzi, T., & Karmiloff-Smith, A. (2002). Early categorization abilities in young children with Williams syndrome. *NeuroReport*, *13*, 1259-1262. doi:10.1097/00001756-200207190-00008

Oviatt, S. L. (1980). The emerging ability to comprehend language: An experimental approach. *Child Development, 51*, 97-106. doi: 10.2307/1129662

Pater, J., Stager, C., & Werker, J. F. (2004). The perceptual acquisition of phonological contrasts. Language, 80, 384-402. doi: 10.1515/lp-2012-0007

Preissler, M. A., & Carey, S. (2004). Do both pictures and words function as symbols for 18-and 24-month-old children?. *Journal of Cognition and Development*, *5*(2), 185-212. doi: 10.1207/s15327647jcd0502_2

Pruden, S. M., Hirsh-Pasek, K., Golinkoff, R. M., & Hennon, E. A. (2006). The Birth of Words: Ten-Month-Olds Learn Words Through Perceptual Salience. *Child development*, *77*(2), 266-280. doi: 10.1111/j.1467-8624.2006.00869

Schafer, G., & Plunkett, K. (1998). Rapid word learning by fifteen-month-olds under tightly controlled conditions. *Child Development, 69*, 309-320. doi: 10.1111/j.1467-8624.1998.tb06190.x

Slater, A., Quinn, P. C., Brown, E., & Hayes, R. (1999). Intermodal perception at birth: Intersensory redundancy guides newborn infants' learning of arbitrary auditory–visual pairings. *Developmental Science*, *2*(3), 333-338. doi: 10.1111/1467-7687.00079

Stager, C. L., & Werker, J. F. (1997). Infants listen for more phonetic detail in speech perception than in word-learning tasks. *Nature, 388*, 381-382. doi:10.1038/41102

Swingley, D., & Aslin, R. N. (2002). Lexical neighborhoods and the word-form representations of 14-month-olds. *Psychological Science*, *13*(5), 480-484. doi: 10.1111/1467-9280.00485

Thiessen, E. D., Hill, E. A., & Saffran, J. R. (2005). Infant-directed speech facilitates word segmentation. *Infancy*, *7*(1), 53-71. doi:10.1207/s15327078in0701_5

Thomas, M. S., Grant, J., Barham, Z., Gsödl, M., Laing, E., Lakusta, L. et al. (2001). Past tense formation in Williams syndrome. *Language and Cognitive Processes*, *16*(2-3), 143-176. doi:10.1080/01690960042000021

Thurman, A. J., & Mervis, C. B. (2013). The regulatory function of social referencing in preschoolers with Down syndrome or Williams syndrome. *Journal of neurodevelopmental disorders*, *5*(1), 1-20. doi:10.1186/1866-1955-5-2

Torkildsen, J. V. K., Svangstu, J. M., Hansen, H. F., Smith, L., Simonsen, H. G., Moen, I., & Lindgren, M. (2008). Productive vocabulary size predicts event-related potential correlates of fast mapping in 20-month-olds. *Journal of cognitive neuroscience*, *20*(7), 1266-1282. doi:10.1162/jocn.2008.20087

Waxman, S. R., & Gelman, S. A. (2009). Early word-learning entails reference, not merely associations. *Trends in cognitive sciences*, *13*(6), 258-263. doi:10.1016/j.tics.2009.03.006

Werker, J. F., Cohen, L. B., Lloyd, V., L., Casasola, M. & Stager, C. L. (1998). Acquisition of word – object associations by 14-month-old infants. *Developmental Psychology, 34*, 1289 – 1309. doi:10.1037/0012-1649.34.6.1289

Werker, J. F., Fennell, C. T., Corcoran, K. M., & Stager, C. L. (2002). Infants' ability to learn phonetically similar words: Effects of age and vocabulary size. *Infancy, 3*, 1-30. doi:10.1207/S15327078IN0301_1

Werker, J. F., & Yeung, H. H. (2005). Infant speech perception bootstraps word learning. *Trends in cognitive sciences*, *9*(11), 519-527. doi:10.1016/j.tics.2005.09.003

Williams, K. T. (2007). *Expressive Vocabulary Test (2nd ed.)*. Minneapolis, MN: Pearson Assessments.

Woodward, A., L., Markman, E. M., & Fitzsimmons, C. M. (1994). Rapid word learning in 13- and 18-month-olds. *Developmental Psychology, 30*, 553-366. doi: 10.1037/0012-1649.30.4.553

Yoshida, K. A., Fennell, C. T., Swingley, D., & Werker, J. F. (2009). Fourteen-month-old infants learn similar-sounding words. *Developmental science*, *12*(3), 412-418. doi: 10.1111/j.1467-7687.2008.00789.x

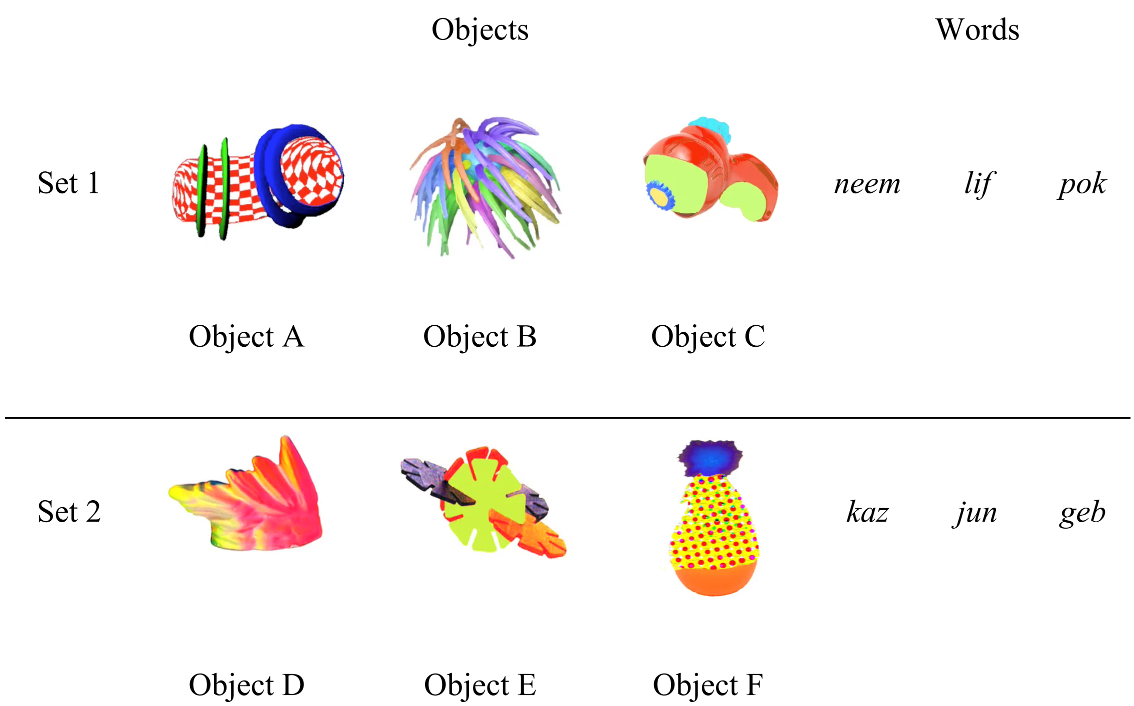

Figure 1. Six objects and six words that were used to create the word–object pairs in set 1 and set 2.

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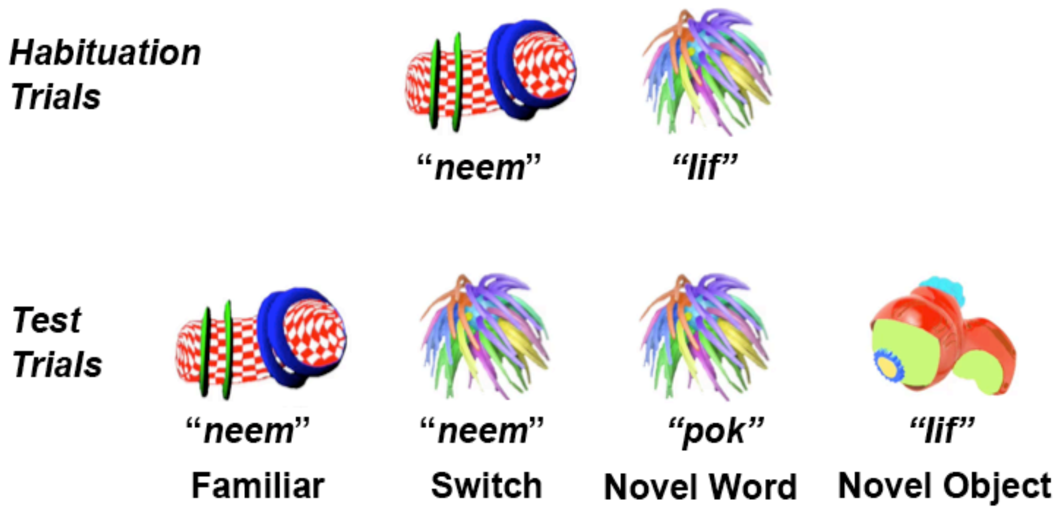


Figure 2. Examples of the habituation and test stimuli.

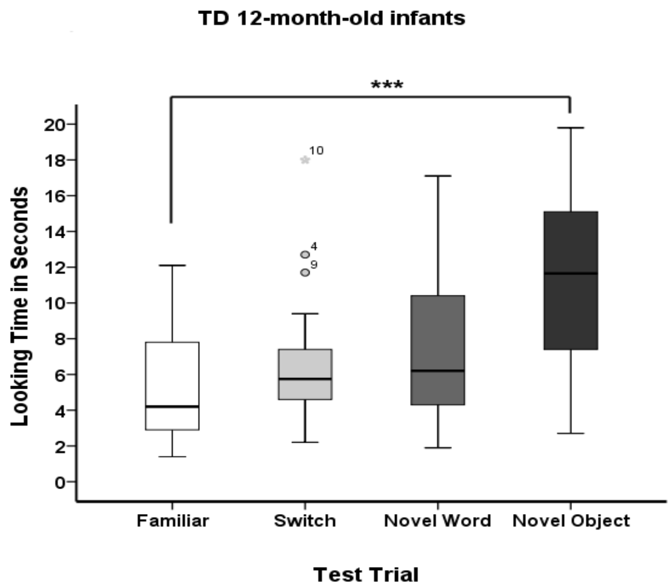
Table 1

Looking times on the test trials, the difference scores, and the vocabulary sizes for TD 12- and 14-month-old TD infants

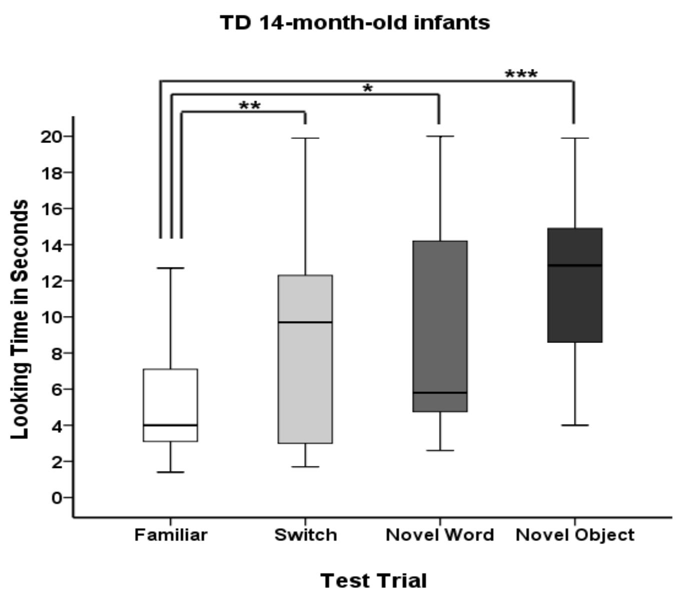
Group	LT				Difference Score			Vocabulary Size	
	F	S	NW	NO	SD	NWD	NOD	RV	EV
12									
M	5.58	6.59	7.70	11.31	1.01	2.02	5.73	39.00	6.91
Mdn	4.20	5.75	6.20	11.65	.90	2.80	4.35	39.50	5.50
SD	3.40	3.71	4.32	5.08	5.33	5.16	5.34	25.76	5.54
n	22	22	21	22	22	21	22	22	22
14									
M	5.18	8.84	9.37	12.41	3.66	3.85	7.23	82.33	15.22
Mdn	4.00	9.70	5.80	12.85	2.65	3.20	7.15	59.00	13.00
SD	3.36	5.77	6.66	5.13	4.65	6.50	5.09	52.62	8.54
n	18	18	15	18	18	15	18	18	18
All									
M	5.40	7.60	8.39	11.81	2.20	2.78	6.41	58.50	10.65
Mdn	4.00	6.00	5.80	11.80	2.15	2.85	5.80	48.00	9.00
SD	3.35	4.82	5.40	5.07	5.15	5.74	5.22	45.18	8.11
n	40	40	36	40	40	36	40	40	40

Note. 12 = 12-month-old infants; 14 = 14-month-old infants; LT = Looking time; F = familiar; S = switch; NW = novel word; NO = novel object; SD = switch difference score; NWD = novel word difference score; NOD = novel object difference score; RV = receptive vocabulary size; EV = expressive vocabulary size.

(3a)



(3b)



Figures 3a and 3b. Looking times during the four test trials in TD 12-month-old infants (*3a*) and in TD 14-month-old infants (*3b*).

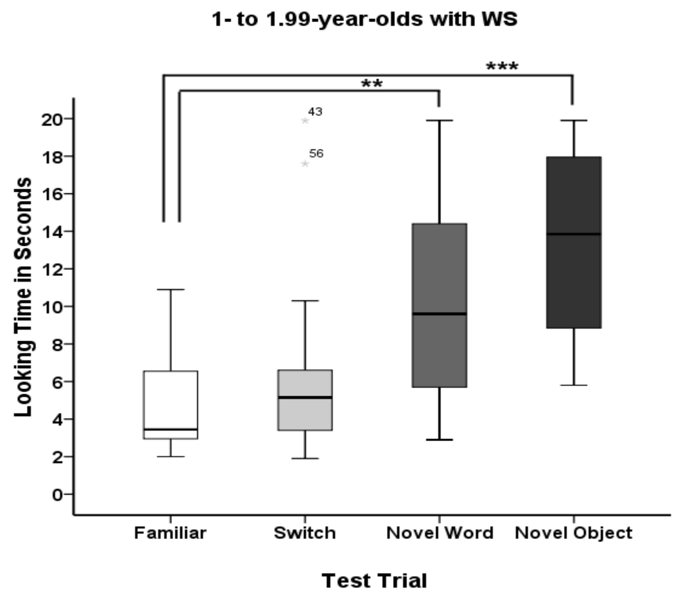
Table 2

Looking times on the test trials, the difference scores, and the vocabulary sizes for 1–1.99-year-olds with WS and 2–2.99-year-olds with WS

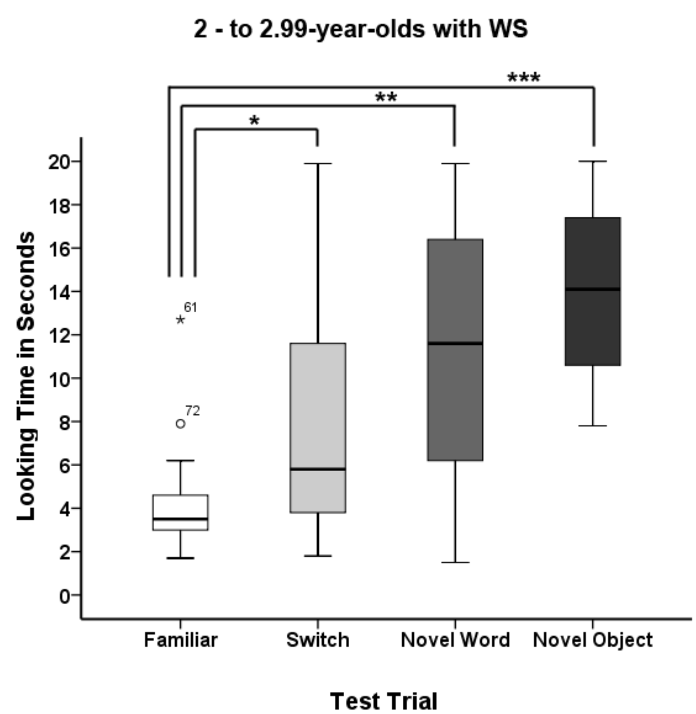
WS	LT				Difference Score			Vocabulary Size	
	F	S	NW	NO	SD	NWD	NOD	RV	EV
YWS									
M	4.79	6.54	10.33	13.57	1.75	5.39	8.78	31.31	7.44
Mdn	3.45	5.15	9.60	13.85	.20	6.10	8.65	14.00	1.00
SD	2.86	5.19	4.97	5.01	5.40	6.32	5.16	38.51	11.31
n	16	16	15	16	16	15	16	16	16
OWS									
M	4.25	8.04	11.39	14.07	3.72	7.14	9.81	202.29	104.41
Mdn	3.50	5.80	11.60	14.10	1.70	7.20	10.10	183.00	66.00
SD	2.74	5.69	6.44	4.40	5.83	6.87	6.15	111.02	110.66
n	17	17	17	17	17	17	17	17	17
All									
M	4.52	7.31	10.89	13.82	2.77	6.32	9.31	119.39	57.39
Mdn	3.50	5.20	11.05	14.10	.80	6.55	8.90	65.00	13.00
SD	2.77	5.42	5.73	4.64	5.63	6.57	5.63	119.95	92.76
n	33	33	32	33	33	32	33	33	33

Note. YWS = 1–1.99-year-olds with WS; OWS = 2–2.99-year-olds with WS; LT = Looking time; F = familiar; S = switch; NW = novel word; NO = novel object; SD = switch difference score; NWD = novel word difference score; NOD = novel object difference score; RV = receptive vocabulary size; EV = expressive vocabulary size

(4a)



(4b)



Figures 4a and 4b. Looking times during the four test trials in the 1–1.99-year-olds with WS (4a) and in the 2–2.99-year-olds with WS (4b).

Appendix A1. Individual case for date analyses inclusion and exclusion in 12-month-old infants.

ID	Age (mos.)	Gender	All Data	Each Data Set					
			Friedman	Wilcoxon			Chi-Square		
				NO	NW	Switch	NO	NW	Switch
1	12.1	F	Y	Y	Y	Y	Y	Y	Y
2	11.7	F	Y	Y	Y	Y	Y	Y	Y
3	11.8	F	**N**	Y	**N**	Y	Y	**N**	Y
4	12.3	F	Y	Y	Y	Y	Y	Y	Y
5	12.0	M	Y	Y	Y	Y	Y	Y	Y
6	11.7	F	Y	Y	Y	Y	Y	Y	Y
7	12.5	M	Y	Y	Y	Y	Y	Y	Y
8	12.3	F	Y	Y	Y	Y	Y	Y	Y
9	12.1	M	Y	Y	Y	Y	Y	Y	Y
10	12.2	F	Y	Y	Y	Y	Y	Y	Y
11	11.8	M	Y	Y	Y	Y	Y	Y	Y
12	11.8	M	Y	Y	Y	Y	Y	Y	Y
13	11.9	F	Y	Y	Y	Y	Y	Y	Y
14	11.7	F	Y	Y	Y	Y	Y	Y	Y
15	12.3	M	Y	Y	Y	Y	Y	Y	Y
16	12.5	M	Y	Y	Y	Y	Y	Y	Y
17	12.1	F	Y	Y	Y	Y	Y	Y	Y
18	11.8	F	Y	Y	Y	Y	Y	Y	Y
19	12.0	M	Y	Y	Y	Y	Y	Y	Y
20	11.8	M	Y	Y	Y	Y	Y	Y	Y
21	11.7	F	Y	Y	Y	Y	Y	Y	Y
22	12.4	M	Y	Y	Y	Y	Y	Y	Y

Appendix A2. Individual case for date analyses inclusion and exclusion in 14-month-old infants.

ID	Age (mos.)	Gender	All Data	Each Data Set					
			Friedman	Wilcoxon			Chi-Square		
				NO	NW	Switch	NO	NW	Switch
23	14.4	F	Y	Y	Y	Y	Y	Y	Y
24	13.8	F	**N**	Y	**N**	Y	Y	**N**	Y
25	13.5	F	Y	Y	Y	Y	Y	Y	Y
26	14.5	M	Y	Y	Y	Y	Y	Y	Y
27	14.2	F	Y	Y	Y	Y	Y	Y	Y
28	14.2	M	Y	Y	Y	Y	Y	Y	Y
29	14.0	F	Y	Y	Y	Y	Y	Y	Y
30	14.2	F	Y	Y	Y	Y	Y	Y	Y
31	13.7	F	Y	Y	Y	Y	Y	Y	Y
32	14.5	F	Y	Y	Y	Y	Y	Y	Y
33	13.6	M	Y	Y	Y	Y	Y	Y	Y
34	14.2	M	Y	Y	Y	Y	Y	Y	Y
35	13.7	F	Y	Y	Y	Y	Y	Y	Y
36	13.8	M	Y	Y	Y	Y	Y	Y	Y
37	13.9	M	Y	Y	Y	Y	Y	Y	Y
38	14.0	M	Y	Y	Y	Y	Y	Y	Y
39	14.2	M	**N**	Y	**N**	Y	Y	**N**	Y
40	14.3	M	**N**	Y	**N**	Y	Y	**N**	Y

Appendix A3. Individual case for date analyses inclusion and exclusion in 1–1.99-year-olds with WS.

ID	Adjusted Age (yrs.)	Gender	All Data	Each Data Set					
			Friedman	Wilcoxon			Chi-Square		
				NO	NW	Switch	NO	NW	Switch
41	1.50	F	Y	Y	Y	Y	Y	Y	Y
42	1.08	F	Y	Y	Y	Y	Y	Y	Y
43	1.57	F	**N**	Y	**N**	Y	Y	**N**	Y
44	1.72	F	Y	Y	Y	Y	Y	Y	Y
45	1.82	M	Y	Y	Y	Y	Y	Y	Y
46	1.65	M	Y	Y	Y	Y	Y	Y	Y
47	1.87	M	Y	Y	Y	Y	Y	Y	Y
48	1.24	F	Y	Y	Y	Y	Y	Y	Y
49	1.80	M	Y	Y	Y	Y	Y	Y	Y
50	1.06	M	Y	Y	Y	Y	Y	Y	Y
51	1.51	F	Y	Y	Y	Y	Y	Y	Y
52	1.32	F	Y	Y	Y	Y	Y	Y	Y
53	1.73	M	Y	Y	Y	Y	Y	Y	Y
54	1.19	M	Y	Y	Y	Y	Y	Y	Y
55	1.55	M	Y	Y	Y	Y	Y	Y	Y
56	1.54	F	Y	Y	Y	Y	Y	Y	Y

Appendix A4. Individual case for date analyses inclusion and exclusion in 2–3-year-olds with WS.

ID	Adjusted Age (yrs.)	Gender	All Data	Each Data Set					
			Friedman	Wilcoxon			Chi-Square		
				NO	NW	Switch	NO	NW	Switch
57	2.22	F	Y	Y	Y	Y	Y	Y	Y
58	2.58	F	Y	Y	Y	Y	Y	Y	Y
59	2.06	F	Y	Y	Y	Y	Y	Y	Y
60	2.52	M	Y	Y	Y	Y	Y	Y	Y
61	2.03	F	Y	Y	Y	Y	Y	Y	Y
62	2.27	M	Y	Y	Y	Y	Y	Y	Y
63	2.67	M	Y	Y	Y	Y	Y	Y	Y
64	2.79	F	Y	Y	Y	Y	Y	Y	Y
65	2.60	F	Y	Y	Y	Y	Y	Y	Y
66	2.32	M	Y	Y	Y	Y	Y	Y	Y
67	2.43	F	Y	Y	Y	Y	Y	Y	Y
68	2.61	M	Y	Y	Y	Y	Y	Y	Y
69	2.58	M	Y	Y	Y	Y	Y	Y	Y
70	2.08	M	Y	Y	Y	Y	Y	Y	Y
71	2.92	M	Y	Y	Y	Y	Y	Y	Y
72	2.95	M	Y	Y	Y	Y	Y	Y	Y
73	2.60	M	Y	Y	Y	Y	Y	Y	Y

Appendix B. Word–object pairs and test stimuli in set 1 and set 2.

Six objects (set 1: *objects A, B, C*, set 2: *objects D, E, F*) and six nonsense words (set 1: *lif, neem, pok*, set 2: *kaz, jun, geb*) were used to create two stimulus sets (see Figure 1). Within each set, two objects and two nonsense words were used to create the habituation and switch test word–object pairs, and one word and one object were used for creating novel test pairs. In stimulus set 1, the habituation word–object pairs and the switch test stimuli were created by combining the words *neem* and *lif* with *objects A* and *B*. The novel word test stimuli were created by combining the novel word *pok* with one of the habituation objects, *object A* or *B*. The novel object test stimuli were created by combining a novel object, *object C,* with one of the habituation words, *neem* or *lif*. In stimulus set 2, the words *kaz* and *jun* were combined with *objects D* and *F* to create the habituation and switch test word–object pairs in this set. The novel word used in this set was always *geb,* and the novel object used in this set was always *object F*.

(*Appendix B continued*)

	Habituation Trials		Test Trials			
	Pair 1	Pair 2	Familiar	Switch	Novel Word	Novel Object
Set 1	object A /neem	object B /lif	object A /neem	object A /lif	object A /pok	object C /neem
			object B /lif	object A /lif	object B /pok	object C /lif
	object A /lif	object B /neem	object A /lif	object B /lif	object A /pok	object C /lif
			object B /neem	object B /lif	object A /pok	object C /neem
Set 2	object D /kaz	object E /jun	object D /kaz	object D /jun	object E /geb	object F /jun
			object E /jun	object D /jun	object E /geb	object F /kaz
	object D /jun	object E /kaz	object D /jun	object D /kaz	object D /geb	object F /kaz
			object E /kaz	object D /kaz	object D /geb	object F /jun

CURRIMULUM VITAE

Oh Ryeong Ha

CONTACT

Work address: Department of Psychological and Brain Sciences

University of Louisville

Louisville, KY 40292

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EDUCATION

University of Louisville, Louisville, KY 2007 – present

Ph.D., Experimental Psychology (expected May, 2013)

Concentration in Cognitive and Developmental Sciences

Advisor: Cara H. Cashon, Ph.D

Korea University, Seoul, Korea 1997 - 2000

M.A., Clinical Psychology

Advisor: Junghye Kwon, Ph.D.

Seoul Women's University, Seoul, Korea 1993 - 1997

B.A., Educational Psychology (Minor: English Language & Literature)

AWARDS, SCHOLORSHIPS, and FELLOWSHIPS

The Graduate Dean's Citation Award	May 2013
University of Louisville University Fellowship	08/2007 – 06/2009
Academic Achievement Grant, Seoul Women's University	Fall 1996
	Fall 1995
	Spring 1995
Scholarship for the outstanding academic excellence,	Spring 1994
Seoul Women's University	Fall 1993

PROFESSIONAL HISTORY

Graduate Teaching Assistant, University of Louisville	08/2010 – 04/2012
Graduate Research Assistant, University of Louisville	08/2007 – present
Infant Cognition Lab	
Collaborations with Neurodevelopmental Sciences Lab (PI: Dr. Carolyn B. Mervis)	
Clinical Psychologist at Bright Mind Clinic	05/2007 – 07/2007
Clinical Psychologist at Dr. Jeon Clinic	05/2007 – 07/2007
Clinical Psychologist at Dr. Jeon Clinic	03/2005 – 07/2005
Counselor, Student Counseling Center, Korea University	09/2004 – 07/2005
Clinical Psychology Resident, Ajou Medical Center	03/2001 – 03/2002
Clinical Psychology Intern	03/2000 – 02/2001
Department of Psychiatry, Inje University Baik Hospital	
Research Assistant / Therapist	03/2000 – 02/2001
Panic Disorder Clinic, Inje University Baik Hospital	

TEACHING EXPERIENCE

Graduate Teaching Assistant, University of Louisville	Spring 2012
Developmental Psychology (Undergraduate)	
Instructor, University of Louisville	Fall 2011

Advanced Statistics I, Lab section (Graduate)

Instructor, University of Louisville Spring 2011

Advanced Statistics II, Lab section (Graduate)

Instructor, University of Louisville Fall 2010

Advanced Statistics I, Lab section (Graduate)

RESEARCH EXPERIENCE

Research on cognitive, perceptual, and linguistic development in typically developing infants using the traditional looking time measure and eye-tracking

Research on cognitive, perceptual, and linguistic development in infants and toddlers with Williams syndrome

Research on psychological well-being in general adult populations and adults with panic disorder

PUBLICATIONS

Cashon, C. H., **Ha, O. R.**, DeNicola, C. A., & Mervis, C. B. (in press). Toddlers with Williams syndrome process upright but not inverted face holistically. *Journal of Autism and Developmental Disorders*.

Cashon, C. H., **Ha, O. R.**, Allen, C. L., & Barna, A. C. (2012). A U-shaped relation between sitting ability and upright face processing in infants. *Child Development.* doi: 10.1111/cdev.12024

Ha, O. R. & Kwon, J.H. (2006). Mental health and role satisfaction of working mothers: Role conflict, perfectionism, and family/spouse support. *Korean Journal of Clinical Psychology*, *25*, 621-642.

Choi, Y.H., Park, K.H., Kim, H.S., & **Ha, O. R.** (2000). Predicting factors of discontinuation of medication after cognitive behavioral therapy for panic disorder. *Journal of the Korean Society of Biological Psychiatry*, *7*, 157-161.

CONFERENCE PRESENTATIONS

Cashon, C. H., DeNicola, C. A., **Ha, O. R.**, Estes, K. G., Saffran, J. R., & Mervis, C. B. (2012, July). *Statistical learning of linguistic input by infants and toddlers with*

Williams syndrome. Poster presented at the 13th International Williams Syndrome Association Conference, Boston, MA.

Cashon, C. H., **Ha, O. R.**, DeNicola, C. A., & Mervis, C. B. (2012, June). *Toddlers with Williams syndrome process relational information in upright but not in inverted faces*. Poster presented at the International Conference on Infant Studies, Minneapolis, MN. (Also presented at the 13th International Williams Syndrome Association Conference, July 2012, Boston, MA.)

Cashon, C. H., DeNicola, C. A., **Ha, O. R.**, Becerra, A. M., & Mervis, C. B. (2011, April). *Two- to three-year-olds with Williams syndrome associate novel words and novel objects*. Poster presented at the biennial meeting of the Society for Research in Child Development, Montreal, Quebec, Canada.

Sams, P. K., DeNicola, C. A., **Ha, O. R.**, & Cashon, C. H. (2011, April). *Word–object associations in toddlers with Williams syndrome*. Poster presented at the University of Louisville Undergraduate Research Symposium.

Dyer, E., **Ha, O. R.**, & Cashon, C. H. (2010, April). *Second-order configural processing of faces in 10-month-old infants*. Poster presented at the University of Louisville Undergraduate Research Symposium.

Ha, O. R., & Cashon, C. H. (2010, April). *Using habituation to test configural processing of faces in 7- and 10-month-old infants*. Poster presented at the International Conference on Infant Studies, Baltimore, MD.

Cashon, C. H., **Ha, O. R.**, Allen, C. L., & Mervis, C. B. (2009, April). *Infants and toddlers with Williams syndrome demonstrate the "face inversion effect."* Poster presented at the biennial meeting of the Society for Research in Child Development, Denver, CO.

Cashon, C. H., **Ha, O. R.**, Allen, C. L., Estes, K. G., Saffran, J. R., & Mervis, C. B. (2009, April). *9- to 21-month-olds with Williams syndrome are statistical learners*. Poster presented at the biennial meeting of the Society for Research in Child Development, Denver, CO.

Cashon, C. H., **Ha, O. R.**, Allen, C. L., & Barna, A. C. (2009, April). *Processing of upright faces differs by sitting ability in 5.5- and 6.5-month-old infants*. Poster presented at the biennial meeting of the Society for Research in Child Development, Denver, CO.

Ha, O. R., Allen, C. L., Barna, A. C., & Cashon, C. H. (2009, March). *Sitting ability is related to face processing in 7-month-old infants*. Poster presented at the University of Louisville Graduate Research Symposium.

Choi, Y.H., Park, K.H., & **Ha, O. R.** (2000, October). *Panic symptoms and alexithymia*. Poster presented at the annual meeting of the Korean Neuropsychiatry Association, Seoul, Korea.

Ko, E.J., Choi, Y.H., Park, K.H., & **Ha, O. R.** (2000, October). *The characteristic distress of panic patients with agoraphobia*. Poster presented at the annual meeting of the Korean Neuropsychiatry Association, Seoul, Korea.

Choi, Y. H., Park, K. H., Kim, H. S., & **Ha, O. R.** (2000, October). *Predicting factors of discontinuation of medication after cognitive behavioral therapy for panic disorder*. Poster presented at the annual meeting of the Korean Neuropsychiatry Association, Seoul, Korea.

Ha, O. R. & Kwon, J. H. (2000, July). *The influence of role conflict, perfectionism, and family support on psychological adjustment of working women*. Poster presented at the annual meeting of the Korean Society for Clinical Psychology, Seoul, Korea.

INVITED TALK

Configural face processing in typically developing infants and infants and toddlers with Williams Syndrome. Presented at the Experimental Psychology Seminar, University of Louisville, April 2010.

CLINICAL EXPERIENCE

Comprehensive Psychological Evaluation & Developmental assessment: Adult psychological tests, child and adolescent psychological and developmental tests, and neuropsychological tests

Psychological Therapy: Individual counseling, CBT for Panic Disorder, Relaxation training

CERTIFICATES

Mental Health Psychologist (Class II), Korea	2000
Secondary School Teacher (Grade II) of English, Korea	1997
Secondary School Teacher (Grade II) of Psychology, Korea	1997
Adult and Continuing Education Educator, Korea	1997

ACTIVITIES

Vice-President, Educational Psychology Students Association,
Seoul Women's University 03/1995 – 02/1996

President of freshmen, Educational Psychology Students Association,
Seoul Women's University 09/1993 – 02/1994

MEMBERSHIP

The International Society on Infant Studies

The Korean Society for Psychology

The Korean Society for Clinical Psychology