Published in final edited form as:

Dev Sci. 2020 November ; 23(6): e12966. doi:10.1111/desc.12966.

Development of Rapid Word-Object Associations in Relation to Expressive Vocabulary: Shared Commonalities in Infants and Toddlers with and without Williams Syndrome

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Abstract

Associative word learning, i.e., associating a word with an object, is an important building block of early word learning for TD infants. The present study investigated the development of word-object associations by TD infants and infants and toddlers with Williams syndrome (WS), a rare genetic disorder associated with delayed language and cognitive development. The specific reasons for the language delays are unknown. We investigated whether their early language delay could be related to differences in how word-object associations are formed. Fifty-nine 11- to 14-month-old TD infants and thirty-one 12- to 35-month-olds with WS were tested on a modified version of the “switch” task (Werker, Cohen, Lloyd, Casasola, & Stager, 1998) using phonetically dissimilar words and novel objects. Infants were classified as word-learners or novice word-learners based on their expressive vocabularies (greater than 10 words vs. 10 words or fewer). We found similar developmental patterns across both populations: Expressive vocabulary size classification was an important index of the development of word-object associations. Moreover, the development of word-object associations evidenced a domain-general progression from independent (processing objects separately from words) to integrated (processing associations between words and objects). As a group, word-learners formed word-object associations, but novice word-learners did not; instead, they focused primarily on the objects. Findings build on previous research suggesting that although early language acquisition is delayed in infants with WS, infants and toddlers with and without WS share a common developmental pattern and set of mechanisms in early word learning.

Keywords

Williams syndrome; Word-object associations; Language development; Language delay; Word learning; Infancy

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Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Data Availability Statement

The data that support the findings of this study are openly available in OSF at <http://doi.org/10.17605/OSF.IO/6DZVG>. Ha, O.-R. (2019, April 1). Word learning in infants with and without WS. <https://doi.org/10.17605/OSF.IO/6DZVG>

Associative word learning, a fundamental mechanism in vocabulary acquisition, is indicative of infants' becoming more proficient word learners (Marcus, Fernandes, & Johnson, 2012; Torkildsen et al., 2008; Werker et al., 1998); Werker, Fennell, Corcoran, & Stager, 2002; see meta-analysis by Tsui, Byers-Heinlein, & Fennell, 2019). The purpose of the present study was to investigate whether the general sequence of development of word-object associations by young children with Williams syndrome (WS), a rare genetic disorder that is associated with cognitive and linguistic delays, is similar to that of typically developing (TD) infants and toddlers. In particular, we were interested in comparing the early development of associative word learning (i.e., when the words to be learned are phonetically *dissimilar*) and its relation to expressive vocabulary size. Previous studies have found a relation between expressive vocabulary size and word-object associations in TD infants when the words to be learned were phonetically *similar* (Werker et al., 2002). However, the relation between expressive vocabulary and associative word learning of phonetically *dissimilar* words has not been reported.

Word-Object Associations

The most common method used to investigate word-object associations is the “switch” task (Werker et al., 1998). In its most basic form, infants are habituated to two word-object pairs (e.g., object A/*lif* and object B/*neem*) and then tested with a familiar pair (e.g., object A/*lif*) and a *switch* pair (e.g., object A/*neem*). Longer looking during the switch test compared to the familiar test (i.e., dishabituation to the switch test) is taken as evidence that infants detect the novel word-object combination and can rapidly form word-object associations.

In their initial classic study, which used the phonetically *dissimilar* words, “*lif*” and “*neem*,” Werker et al. (1998) found that 14-month-old TD infants formed word-object associations but younger infants at 8, 10, or 12 months did not. Instead, the younger infants attended to the words and objects but failed to form links between them. Their findings are consistent with the domain-general developmental progression from an independent (in this case, attention to the objects and words separately but not to the word-object associations) to an integrated level of processing also found in areas such as early form perception, object unity, face processing, and causal perception (Cohen, 1998; Cohen & Cashon, 2001, 2003, 2006; Cohen, Chaput, & Cashon, 2002).

A link between expressive vocabulary size and word-object association formation has been found in older TD infants tested with phonetically *similar* words. Specifically, Werker and colleagues (Werker et al., 2002) found that 14- to 20-month-olds with 25 or more words in their expressive vocabulary formed word-object associations with phonetically similar words. In contrast, same-aged infants with fewer than 25 words in their expressive vocabulary did not. Whether expressive vocabulary size is related to word-object association formation when the target words are phonetically dissimilar – an earlier emerging skill – has not yet been addressed.

Williams Syndrome

WS is a rare genetic neurodevelopmental disorder associated with intellectual disability, a distinctive weakness in visuospatial construction, and relative strengths in face processing, verbal short-term memory, phonological processing, and concrete language (Howlin, Davies, & Udwin, 1998; Howlin, Elison, Udwin, & Stinton, 2010; Mervis, 2009; Mervis & John, 2012; Mervis et al., 2000). Although concrete vocabulary is a relative strength, vocabulary acquisition during the first three years of life is significantly delayed. To illustrate, 18-month-olds with WS have a median expressive vocabulary size of 1 word (IQR = 0 – 5 words; Mervis, Becerra, Pitts, & Marchman, 2019); at the same age, TD infants have a median expressive vocabulary size of 86 words (IQR = 37 – 170; Fenson et al., 2007). An expressive vocabulary size of 86 words is not typically observed in children with WS until age 31 months (Mervis et al., 2019).

Although this early language delay in WS is well documented, the reasons for the delay are not known. At this point, only a handful of studies have been conducted on the mechanisms that underlie early language acquisition in infants and toddlers with WS (e.g., Becerra & Mervis, in press; D'Souza, D'Souza, Johnson, & Karmiloff-Smith, 2016; Mervis & Bertrand, 1997; Nazzi & Bertoncini, 2003). It is also unknown whether young children with WS are able to use similar early word learning mechanisms to those used by TD infants and are just delayed or whether young children with WS acquire language differently. A recent study of 8- to 20-month-olds with WS indicated that, as has been found in TD 8-month-olds, very young children with WS (including infants with chronological ages of 8 – 11 months) can use statistical learning to segment words (Cashon, Ha, Estes, Saffran, & Mervis, 2016). Although the chronological ages of the participants with WS in their study were almost all older than 8 months, their median receptive vocabulary age was < 8 months, which is slightly younger than the chronological age of the TD infants tested by Saffran et al. (1996). This result should not be interpreted to mean that the statistical learning abilities of infants with WS appear as early in development as they do in TD infants. However, it does indicate that statistical learning is available to young children with WS well before the age at which they begin to talk. In sum, the results of the Cashon et al. study suggest that it is unlikely that an inability to engage in statistical learning is the primary reason for their language acquisition delays. It is possible that the reason(s) for their language delay are the same as those for their intellectual disability. However, other early word-learning mechanisms need to be studied before that conclusion can be made.

Because of the important role that associative word learning plays in language acquisition, understanding how young children with WS develop this ability and how that development may be similar to or different from that of TD infants may provide important insight into reasons for their language delay. Although previous research has reported that children with WS aged 3 – 8 years (mean age = 5 years, 3 months) were able to fast map phonetically similar words to corresponding referents (Havy, Moukawane, & Nazzi, 2010), the earlier-emerging ability to form word-object associations with *dissimilar* words has not yet been investigated in infants or toddlers with WS.

The Present Project

In the present study, we compared the development of early word-object association formation using phonetically dissimilar words and its relation to expressive vocabulary size in infants and toddlers with and without WS. We tested TD infants aged 11 to 14 months and infants and toddlers with WS aged 12 to 35 months in a habituation “switch” task with phonetically *dissimilar* words based on Werker et al. (1998). We assessed expressive vocabulary size by asking parents to complete the MacArthur-Bates Communicative Developmental Inventory: Word and Gestures (Fenson et al., 2007). The age ranges selected were intended to capture early word-learners in each group. Recall that, using a similar task, Werker et al. (1998) found that TD 14-month-olds formed word-object associations, but TD infants at 8, 10, and 12 months did not. Due to their language delays, the infants and toddlers with WS in our study were older than the TD infants we tested, but they were expected to be at a comparable stage of early word-learning (Havy, Moukawane, & Nazzi, 2010).

Due to the fundamental nature of word-object association formation in early word learning, we hypothesized that infants and toddlers with WS would form word-object associations in a developmentally similar manner to that of TD infants. That is, across both populations (TD and WS), we hypothesized that novice word-learners (i.e., those with very small expressive vocabularies) would not process word-object associations, whereas word-learners (i.e., those with larger expressive vocabularies) would process word-object associations. To test this hypothesis, we created small and large expressive vocabulary groups in each population using the median expressive vocabulary size of the TD group (the control group). This approach was modeled after the findings of Werker et al. (2002), who found that an expressive vocabulary size of 25 words differentiated TD infants (ages 14 – 20 months) who did and did not form word-object associations when phonetically similar word pairs were used.

Method

Participants

The final sample included 59 full-term, healthy 11- to 14-month-old TD infants (31 girls, 28 boys; $M_{\text{age}} = 12.98$ months, $SD = 0.88$, range = 11.70 – 14.49) and 31 infants and toddlers with a genetically confirmed classic-length deletion of the WS region of chromosome 7q11.23 between the ages of 12 and 35 months (13 girls, 18 boys; $M_{\text{age}} = 24.57$ months, $SD = 6.74$, range = 12.68 – 35.41). All participants had normal or corrected-to-normal vision and normal hearing.

None of the TD participants had any reported developmental concerns or delays. All participants with WS completed the Mullen Scales of Early Learning (MSEL; Mullen, 1995), a standardized assessment of early cognitive and language development, as part of a larger longitudinal study in another lab. Twenty-four of the 31 children completed the MSEL within 1 month of the test date for the word-object switch task. The remaining participants completed the MSEL at a different time, ranging from approximately 1 to 5 months before completing the word-object switch task to 2 months after (median: 1.8 months before). The MSEL Early Learning Composite (ELC; age-standardized mean = 100, $SD = 15$) is reported

here for descriptive purposes. Mean MSEL ELC was 66.59 ($SD = 15.10$, median = 64, IQR = 52 – 81), with a range from 49 (the lowest possible MSEL ELC, earned by two participants) – 99. These standard scores indicate that on average, the participants evidenced mild developmental delay, with a range from moderate-severe developmental delay to average ability for the general population. This pattern is consistent with prior Mullen ELC findings for large samples of infants, toddlers, and young preschoolers with WS (Mervis & John, 2010).

Thirty additional TD infants were excluded for the following reasons: fussiness ($n = 5$), parent interference ($n = 4$), not meeting the habituation criterion ($n = 7$), not being fully habituated ($n = 3$), looking away before the word was presented on at least one test trial ($n = 6$), and experimenter error ($n = 5$). Thirteen additional children with WS were excluded for the following reasons: fussiness ($n = 7$), parent interference ($n = 1$), not meeting the habituation criterion ($n = 1$), not being fully habituated ($n = 2$), looking away before the word was presented on at least one test trial ($n = 1$) and experimenter error ($n = 1$).

The TD participants were recruited primarily from a list of infants born in the local area provided by the Kentucky Cabinet for Health and Family Services. Letters of invitation were sent to parents of potentially eligible infants and follow-up phone calls were made by staff to answer questions and schedule appointments. The participants with WS were volunteers from across the United States who were enrolled in a larger study in another lab in the same department. All infants and toddlers with WS who were within the age range included in the present study were invited to enroll in the present study during their visit to the other lab, and the parents of each of these children agreed for them to participate. All participants received a small gift.

Stimuli

A total of six objects and six words was used to create two sets of eight digital movies, each displaying a different word-object pair (see Figure 1). The objects were pictures of unusual toys or shapes obtained from the NOUN Database (Horst & Hout, 2016) or the internet. Pictures were modified to make them more colorful and unusual looking using Adobe® Photoshop®. Phonetically dissimilar, consonant-vowel-consonant (CVC) nonsense words spoken by an adult female, native English speaker using infant-directed speech were used. We used the same words as in Werker et al. (1998) (i.e., *lif*, *neem*, and *pok*) for the first set and recorded new words for the second set (i.e., *kaz*, *jun*, and *geb*). Within each set, two objects (e.g., Objects A and B) and two words (e.g., “*lif*” and “*neem*”) were crossed to create four word-object pairs, which were used as both habituation and test stimuli across participants. A third object (e.g., Object C) and a third word (e.g., “*pok*”) always served as the novel object and novel word in the novel test pairings within each set. In each movie, an object moved back and forth horizontally across the screen (Werker et al., 1998; Experiment 4). The object was animated using Adobe® After Effects®. Each movie began with an average of 1.37 sec of silence, followed by the first presentation of a word. The word was spoken, with some variation of vocal pitch, 9 times in each 20 sec. trial.

Procedure

We used a modified version of the habituation “switch” task with phonetically *dissimilar* words used in Werker et al. (1998). We made three modifications: (1) A within-subject task was created by incorporating test conditions from Werker et al.’s Experiments 3 and 4 into our task, which allowed us to assess whether infants attended to the word-object associations, the objects only, the words only, or both the words and the objects but not the associations, in one testing session. (2) To better meet the needs of infants with WS, who showed longer looking times at stimuli in prior studies (e.g., Cashon, Ha, DeNicola, & Mervis, 2013; Cashon, Ha, Graf Estes, Saffran, & Mervis, 2016), the maximum number of habituation trials was increased from 20 to 30 trials and a sliding window of the six consecutive trials with the highest total looking time was used to calculate the denominator of the habituation criterion instead of using the first four trials (Oakes, 2010). Thus, a participant was considered to have habituated when his/her mean looking time on six consecutive trials (using a sliding window) was less than 50% of the mean looking time on the six consecutive trials with the longest mean looking time. (3) To be more comparable with the novelty of the nonsense words, instead of relatively familiar objects (e.g., dog and truck toy pictures), colorful and unusual looking objects were created.

Each infant was randomly assigned to one of two stimulus sets (see Figure 2). During the habituation phase, each infant was presented with two word–object pairs (e.g., *object A/ neem*, *object B/lif*) sequentially in a quasi-random order. The habituation phase continued until the habituation criterion had been met, which was followed by the test phase automatically. If an infant did not meet the habituation criterion in the maximum number of habituation trials, the infant was excluded from the sample. During the test phase, four word-object pairs were presented to the infant, one at a time: familiar (i.e., one of the habituated pairs, e.g., *object A/neem*), switch (i.e., a novel pairing between familiar word and familiar object, e.g., *object B/neem*), novel word (i.e., a novel word-familiar object pair, e.g., *object B/pok*), and novel object (i.e., a familiar word-novel object pair, e.g., *object C/lif*). The order of the test trials was determined based on a Latin-square design.

For the testing, each infant was seated on an adult’s lap approximately 120 cm from a Panasonic 50” color plasma screen (1024 × 576 pixel resolution) presenting movies in a dimly lit room. To minimize distractions, the adult was instructed not to interact with the infant during testing. In an adjacent room, the experimenter viewed the infant on a 15” JVC monitor that was connected to a closed-circuit Canon Vc-C50i camera hidden below the center of the plasma screen. The experimenter controlled the stimulus presentation and recorded looking times by key presses using Habit X software (Cohen, Atkinson, & Chaput, 2004) running on a Macintosh Power Mac G5. Before each trial, an attention-getter (digital movie of an expanding and contracting green ball on a black background accompanied by a “dinging” sound) was played in the center of the screen. When the infant’s attention was directed at center of the screen, the experimenter presented a movie and recorded the infant’s looking times. Each trial ended when the infant looked away for at least 1 continuous second or when the maximum looking time per trial (20 seconds) had elapsed. The habituation phase continued until Habit X had calculated that the infant’s looking time had reached the habituation criterion. 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. Sessions were recorded for reliability testing. To evaluate reliability, a second experimenter ran Habit X offline while viewing a video of each participant. The correlation between the looking times recorded by the live experimenter and the offline experimenter was $r = .99$.

The estimate of participants' expressive vocabulary size (EV) was based on parental responses on the 396-word vocabulary checklist included in the MacArthur-Bates Communicative Developmental Inventory: Word and Gestures (Fenson et al., 2007). This form was completed within one day of the habituation task. Parents were instructed to mark with an S each word that the child both understood and said spontaneously (not in imitation or as part of a song or other routine), to mark with an M (for "manual sign") each word that the child both understood and signed spontaneously (not after someone else had said or signed the word and not as part of a song or other routine), and mark with a B (for "both") each word that the child understood, said, and signed spontaneously. The child's expressive vocabulary (EV) was the total number of words the parent marked "S," "M," or "B."

Results

Expressive Vocabulary (EV) Groups

To compare the developmental patterns of word-object association formation for TD infants and infants and toddlers with WS, we first divided participants into small and large EV groups. The median EV for the TD group (10 words; IQR = 4 – 16) was used to divide children into small and large EV groups in both populations because the TD group was the referent group for this study. The median EV for the WS group was 13 words (IQR = 1 – 68). Participants in both populations with 10 or fewer words were assigned to the small EV group [TD: $n = 31$, $M_{\text{age}} = 12.57$ months, $SD = 0.78$, range = 11.70 – 14.49; WS: $n = 13$, $M_{\text{age}} = 21.00$ months, $SD = 7.06$, range = 12.68 – 35.09]. Participants whose EV included more than 10 words were assigned to the large EV group [TD: $n = 28$, $M_{\text{age}} = 13.43$ months, $SD = 0.77$, range = 11.86 – 14.49; WS: $n = 18$, $M_{\text{age}} = 27.14$ months, $SD = 5.31$, range = 18.07 – 35.41].

Habituation

Preliminary analyses were conducted to compare the habituation performance of the TD and WS groups at each EV level. Independent-sample t -tests were conducted on mean number of trials to meet the habituation criterion and mean total duration of stimulus exposure during the habituation trials in the small and large EV groups. In the small EV group, no statistically significant difference between populations was found in mean number of habituation trials [TD: $M = 15.4$, $SD = 3.6$; WS: $M = 16.9$, $SD = 4.0$; $t(42) = -1.29$, $p = .21$, $d = .43$] or mean total duration of stimulus exposure during habituation [TD: $M = 146.7$ s, $SD = 59.4$; WS: $M = 174.5$ s, $SD = 59.7$; $t(42) = -1.42$, $p = .16$, $d = .47$]. Similarly, in the large EV group, no statistically significant effect of population was found in mean number of habituation trials [TD: $M = 15.9$, $SD = 4.4$; WS: $M = 18.0$, $SD = 3.9$; $t(44) = -1.64$, $p = .11$, $d = .50$] or mean total duration of stimulus exposure during habituation [TD: $M = 176.1$ s, $SD = 65.0$; WS: $M = 203.9$, $SD = 76.6$; $t(44) = -1.32$, $p = .19$, $d = 0.40$].

EV Group and Word-Object Associations

Mean looking times during test trials for participants in the small and large EV groups across both populations are illustrated in Figure 3 (also see Table 1). To test the main hypothesis that participants in both populations with larger EVs would form word-object associations but those with smaller EVs would not, we conducted a separate 2 (population) X 4 (test trials) ANOVA for each EV group. In addition, comparisons were conducted on mean looking times during each of the three novel test trials compared to that of the familiar test for each population within each EV group. For these planned comparisons, α was set at .017 (.05/3).

In the small EV group, the ANOVA revealed a statistically significant main effect of test trials [$F(2.6, 109.6) = 27.06, p < .001$, partial $\eta^2 = .39$, Huynh-Feldt corrected], but not a statistically significant main effect of population [$F(1, 42) = .75, p = .393$, partial $\eta^2 = .02$]. Contrasts indicated that participants in the small EV group looked significantly longer at the novel word test trial [$F(1, 43) = 9.38, p < .001$, partial $\eta^2 = .18$] and novel object test trial [$F(1, 43) = 61.95, p < .001$, partial $\eta^2 = .59$] compared to the familiar test trial. Consistently with our hypothesis, participants on average in the small EV group did not look significantly longer at the switch compared to the familiar test trial [$F(1, 43) = 2.35, p = .132$, partial $\eta^2 = .05$], indicating that participants in the small EV group did not form word-object associations. A statistically significant Population X Test Trials interaction [$F(2.6, 109.6) = 3.01, p = .033$, partial $\eta^2 = .07$, Huynh-Feldt corrected] was also found. Follow-up independent t -tests did not reveal statistically significant differences in mean looking time between populations on any of the four test trials [familiar: $t(42) = 0.88, p = .383, d = .29$; switch: $t(42) = 1.47, p = .148, d = .49$; novel word: $t(42) = -1.23, p = .227, d = .41$; novel object: $t(42) = -1.94, p = .059, d = .64$]. Given that these differences did not reach statistical significance, an inspection of Figure 3 suggests the interaction was likely due to a similar but slightly exaggerated overall pattern of looking in the WS group compared to that of the TD group.

Planned comparisons (using $\alpha = .017$) conducted separately for each population in the small EV group revealed no statistically significant difference between the familiar and novel word test trials for either group [small EV-TD: $t(30) = -1.94, p = .062, d = .35$; small EV-WS: $t(12) = -2.52, p = .027, d = .70$]. However, for both groups, a significant difference was found between the familiar and novel object test trials [small EV-TD: $t(30) = -5.94, p < .001, d = 1.07$; small EV-WS: $t(12) = -5.75, p < .001, d = 1.60$]. Most importantly, the planned comparisons revealed no significant difference between the familiar and switch test trials in either population [small EV-TD: $t(30) = -1.47, p = .153, d = .26$; small EV-WS: $t(12) = -.46, p = .657, d = .13$], indicating that the small EV groups predominantly attended to the objects and, as predicted, did not form word-object associations (see Figure 3).

In the large EV group, the ANOVA revealed a statistically significant effect of test trials [$F(2.7, 119.0) = 25.61, p < .001$, partial $\eta^2 = .37$, Huynh-Feldt corrected]. Contrasts indicated that on average participants in the large EV group looked significantly longer at the novel word [$F(1, 45) = 24.83, p < .001$, partial $\eta^2 = .36$] and novel object [$F(1, 45) = 87.03, p < .001$, partial $\eta^2 = .66$] tests compared to the familiar, indicating that they processed both the words and the objects. More importantly, they looked significantly longer

at the switch test than the familiar test [$F(1, 45) = 15.19, p < .001$, partial $\eta^2 = .25$], indicating that participants in the large EV group successfully formed word-object associations. Neither a significant main effect for population [$F(1, 44) = 0.62, p = .435$, partial $\eta^2 = .01$] nor a significant Population x Test Trials interaction [$F(2.7, 119.0) = 1.51, p = .214$, partial $\eta^2 = .03$, Huynh-Feldt corrected] was found.

Planned comparisons (using $\alpha = .017$) revealed a similar pattern in the large EV group when test trial data were analyzed separately by population. For both the TD and WS groups, mean looking times were statistically significantly longer during the switch test [large EV-TD: $t(27) = -2.73, p = .011, d = .51$; large EV-WS: $t(17) = -2.78, p = .013, d = .65$], novel word test [large EV-TD: $t(27) = -2.79, p = .010, d = .53$; large EV-WS: $t(17) = -4.68, p < .001, d = 1.10$], and novel object test [large EV-TD: $t(27) = -6.61, p < .001, d = 1.25$; large EV-WS: $t(17) = -6.68, p < .001, d = 1.58$] compared to that of the familiar test. These results are in line with the results of the main effect reported above.

Discussion

In the present study, the development of early word-object association formation with dissimilar words and its relation to expressive vocabulary size was examined in infants and toddlers with and without WS. Consistently with our hypothesis, we found that infants and toddlers with WS formed word-object associations in a developmentally similar manner to that of TD infants. For both populations, more accomplished word-learners (i.e., those with relatively large expressive vocabularies) formed word-object associations, whereas novice word-learners (i.e., those with relatively small expressive vocabularies) did not. These findings are consistent with the domain-general developmental progression of processing one or more features (in this case, the objects) separately to processing relations between features (in this case, word-object associations).

Results of the present study extend our understanding of the relation between expressive vocabulary size and associative word learning in both the TD and WS populations. Previous research has shown that whereas TD toddlers with expressive vocabularies of 25 or more words were likely to form rapid word-object associations even when the words to be learned are phonetically *similar*, a relatively difficult task (Werker et al., 2002), TD toddlers with smaller expressive vocabularies were not. In the present study, we used phonetically *dissimilar* words (resulting in an easier task) and found that infants and toddlers with and without WS who had expressive vocabularies of more than 10 words were likely to form rapid word-object associations whereas infants and toddlers in both populations who had smaller expressive vocabularies were not. Thus, our findings provide evidence that expressive vocabulary size also is related to developmental changes in the *early* emergence of associative word learning, that is, when dissimilar words are used in the standard switch task. Future research should investigate whether the relation between expressive vocabulary size and the ability to form word-object associations with phonetically similar words holds at the group-level not only for TD toddlers who have an EV greater than 25 words (as was found by Werker et al., 2002) but also for toddlers and young preschoolers with WS who have an EV of that size. Havy et al. (2010) have previously shown that older preschoolers and young school-aged children with WS were able to form these types of word-object

associations. However, the participants in that study would have had considerably more than 25 words in their expressive vocabularies, so the expressive vocabulary level at which the formation of word-object associations involving similar words becomes likely for children with WS is unknown. It also would be important to determine if, similarly to the findings of Bernhardt, Kemp, and Werker (2007) for TD children, children with WS who performed well on the switch task at a young age evidence significantly better performance on standardized assessments of language a year or more later than do children who did not form word-object associations on the switch task.

This study was conducted, in part, to better understand early word-learning in young children with WS and possible reasons for their early language acquisition delay. Cashon et al. (2016) previously found that, despite having language delays, 8- to 20-month-olds with WS (including the three youngest children in the sample, all of whom were less than 12 months old) could detect statistical regularities in continuous speech. The results of the present study and those of Cashon et al. provide converging evidence that in the first three years many young children with WS evidence two of the same important early word-learning abilities (i.e., statistical learning and word-object associations with dissimilar words) as do TD infants. An important target for future research is to determine if infants and toddlers with WS can combine these two fundamental skills and use “words” detected by statistical learning to form word-object associations, as TD 17-month infants have been shown to do (Graf Estes, Evans, Alibali, & Saffran, 2007; Hay, Pelucchi, Graf Estes, & Saffran, 2011).

Although the present results provide important insights about early language acquisition, it is still too early to draw strong conclusions about what does or does not account for the language delays in children with WS. Acquiring language is a complex process that involves the integration of many domains. Thus, additional studies are needed in other areas related to early language acquisition. For example, future research could investigate whether the socio-communicative difficulties evidenced by children with WS may contribute to their delay in language learning. In the TD population, a developmental shift from relying on associative cues to relying on social cues for word learning has been found (Golinkoff & Hirsh-Pasek, 2006; Hennon, Chung, & Brown, 2000; Pruden, Hirsh-Pasek, Golinkoff, & Hennon, 2006). Paying attention simultaneously to both referential cues and social cues also improves performance on word learning tasks, including the switch task, in the TD population (Briganti & Cohen, 2011; Fennell & Waxman, 2010). While people with WS are very interested in people, their socio-communicative skills do not develop in a typical manner (Thurman & Mervis, 2013). For example, although TD infants begin to produce referential pointing gestures prior to beginning to produce referential language (Adamson, 1995; Carpenter, Nagell, & Tomasello, 1998), most children with WS begin to produce referential language several months before they begin to point referentially (Becerra & Mervis, in press; Mervis & Bertrand, 1997). Toddlers and young preschoolers with WS evidence considerable difficulty with comprehension of referential pointing gestures relative to both younger TD infants who have much smaller expressive vocabularies (Laing et al., 2002) and same-aged children with Down syndrome who have significantly more limited language abilities (John & Mervis, 2010). Significant difficulties with production of both referential pointing (Klein-Tasman, Mervis, Lord, & Phillips, 2007; Laing et al., 2002) and referential showing gestures

(Klein-Tasman et al., 2007) also have been found. Pruden et al. (2006) have argued that a delayed shift from relying on associative cues to social cues may explain the language delay in populations with less social referential sensitivity. It could be very informative to compare how TD infants and 1- and 2-year-olds with WS incorporate social-referential cues in early word learning.

In summary, our findings provide important evidence of the ability of infants and toddlers with WS to form rapid word-object associations, despite their language delays. Our work also provides insight into the domain-general development of associative word learning and the universality of word-object associations in early word learning. At the same time, the findings of the present study, combined with those of previous research, only begin to address the reasons why the language development of very young children with WS is delayed. Much more research is needed in this complex area.

Acknowledgements

This research was supported by grant R37 HD29957 from the National Institute of Child Health and Human Development, grant R01 NS35102 from the National Institute of Neurological Disorders and Stroke, and grants WSA 0104 and WSA 0111 from the Williams Syndrome Association awarded to Carolyn B. Mervis, and grant P20 RR017702 awarded to Robert Greene (PI) and Cara H. Cashon (Co-I). We would like to thank the children and their parents for participating in these studies and the members of the University of Louisville Infant Cognition Lab and University of Louisville Neurodevelopmental Sciences Lab for assistance with data collection.

References

- Adamson LB (1995). Communication development during infancy. Madison, WI: Brown & Benchmark.
- Bahrack LE, & Lickliter R (2012). The role of intersensory redundancy in early perceptual, cognitive, and social development In Bremner A, Lewkowicz DJ, & Spence C (Eds.), *Multisensory development* (pp. 183–205). Oxford, England: Oxford University Press.
- Becerra AM, & Mervis CB (in press). Age at onset of declarative gestures and expressive vocabulary at 24 months predict later language and intellectual abilities in young children with Williams syndrome. *Frontiers in Psychology* (Special Topic: Precursors to Language Acquisition in Children with Developmental Disorders).
- Bernhardt BM, Kemp N, & Werker JF (2007). Early word-object associations and later language development. *First Language*, 27, 315–328.
- Briganti AM, & Cohen LB (2011). Examining the role of social cues in early word learning. *Infant Behavior and Development*, 34, 211–214. doi:10.1016/j.infbeh.2010.12.012 [PubMed: 21236493]
- Carpenter M, Nagell K, Tomasello M, Butterworth G, & Moore C (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development*, 63(4, Serial No. 255).
- Cashon CH, Ha O-R, DeNicola CA, & Mervis CB (2013). Toddlers with Williams syndrome process upright but not inverted faces holistically. *Journal of Autism and Developmental Disorders*, 43, 2549–2557. 10.1007/s10803-013-1804-0 [PubMed: 23494560]
- Cashon CH, Ha O-R, Graf Estes K, Saffran JR, & Mervis CB (2016). Infants with Williams syndrome detect statistical regularities in continuous speech. *Cognition*, 154, 165–168. 10.1016/j.cognition.2016.05.009 [PubMed: 27299804]
- Cohen LB (1998). An information-processing approach to infant perception and cognition In Simion F & Butterworth G (Eds.), *The development of sensory, motor, and cognitive capacities in early infancy: From perception to cognition* (pp. 277–300). Hove, England: Psychology Press.
- Cohen LB, Atkinson DJ, & Chaput HH (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 LB, & Cashon CH (2001). Infant object segregation implies information integration. *Journal of Experimental Child Psychology*, 78, 75–83; discussion 98–106. doi:10.1006/jecp.2000.2602 [PubMed: 11161425]
- Cohen LB, & Cashon CH (2003). Infant perception and cognition In Lerner RM, Easterbrooks MA, & Mistry J (Eds.), *Handbook of psychology: Developmental psychology*, Vol. 6 (pp. 65–89). New York: Wiley.
- Cohen LB, & Cashon CH (2006). Infant cognition In Damon W & Lerner RM (Series Eds.) & Kuhn D & Siegler R (Vol. Eds.), *Handbook of child psychology*, 6th ed., Vol. 2 (pp. 214–251). New York: Wiley.
- Cohen LB, Chaput HH, & Cashon CH (2002). A constructivist model of infant cognition. *Cognitive Development*, 17, 1323–1343.
- D'Souza D, D'Souza H, Johnson MH, & Karmiloff-Smith A (2016). Audio-visual speech perception in infants and toddlers with Down syndrome, fragile X syndrome, and Williams syndrome. *Infant Behavior and Development*, 44, 249–262. doi:10.1016/j.infbeh.2016.07.002 [PubMed: 27498221]
- Fennell CT, & Waxman SR (2010). What paradox? Referential cues allow for infant use of phonetic detail in word learning. *Child Development*, 81, 1376–1383. doi:10.1111/j.1467-8624.2010.01479.x [PubMed: 20840228]
- Fenson L, Bates E, Dale PS, Marchman VA, Reznick JS, & Thal DJ (2007). *MacArthur-Bates Communicative Development Inventories: User's guide and technical manual*. Baltimore, MD: Brookes.
- Gogate LJ, & Bahrick LE (1998). Intersensory redundancy facilitates learning of arbitrary relations between vowel sounds and objects in seven-month-old infants. *Journal of Experimental Child Psychology*, 69, 133–149. doi:10.1006/jecp.1998.2438 [PubMed: 9637756]
- Gogate LJ, Prince CG, & Matatyaho DJ (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, 508–519. doi:10.1037/a0013623 [PubMed: 19331504]
- Golinkoff RM, & Hirsh-Pasek K (2006). Baby wordsmith: From associationist to social sophisticate. *Current Directions in Psychological Science*, 15, 30–33.
- Graf Estes K, Evans JL, Alibali MW, & Saffran JR (2007). Can infants map meaning to newly segmented words? Statistical segmentation and word learning. *Psychological Science*, 18, 254–60. doi:10.1111/j.1467-9280.2007.01885.x [PubMed: 17444923]
- Hay JF, Pelucchi B, Estes KG, & Saffran JR (2011). Linking sounds to meanings: Infant statistical learning in a natural language. *Cognitive Psychology*, 63, 93–106. doi:10.1016/j.cogpsych.2011.06.002 [PubMed: 21762650]
- Havy M, Moukawane S, & Nazzi T (2010). Are 3-to-8-year-old children with Williams syndrome good word-learners? *NeuroReport*, 21, 882–886. doi:10.1097/WNR.0b013e32833da451 [PubMed: 20671579]
- Hennon E, Chung HL, & Brown E (2000). V. What does it take for 12-month-olds to learn a word? In Hollich GJ, Hirsh-Pasek K, & Golinkoff RM (Eds.) *Breaking the language barrier: An emergentist coalition model of the origins of word learning* (pp. 62–84). *Monographs of the Society for Research in Child Development*, 65(3, Serial No. 262).
- Horst JS, & Hout MC (2016). The Novel Object and Unusual Name (NOUN) Database: A collection of novel images for use in experimental research. *Behavior Research Methods*, 48, 1393–1409. doi:10.3758/s13428-015-0647-3 [PubMed: 26424438]
- Howlin P, Davies M, & Udwin O (1998). Cognitive functioning in adults with Williams syndrome. *Journal of Child Psychology and Psychiatry*, 39, 183–189. [PubMed: 9669231]
- 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, 322–336.
- John AE, & Mervis CB (2010). Comprehension of the communicative intent behind pointing and gazing gestures by young children with Williams syndrome or Down syndrome. *Journal of Speech, Language, and Hearing Research*, 53, 950–960. <https://lshss.pubs.asha.org/doi/10.1044/1092-4388%282009/08-0234%29>

- Jusczyk PW, & Hohne EA (1997). Infants' memory for spoken words. *Science*, 277(5334), 1984–1986. [PubMed: 9302291]
- Klein-Tasman BP, Mervis CB, Lord C, & Phillips KD (2007). Socio-communicative deficits in young children with Williams syndrome: Performance on the Autism Diagnostic Observation Schedule. *Child Neuropsychology*, 13, 444–467. 10.1080/09297040601033680 [PubMed: 17805996]
- Laing E, Butterworth G, Ansari D, Gsödl M, Longhi E, ... Karmiloff-Smith A (2002). Atypical development of language and social communication in toddlers with Williams syndrome. *Developmental Science*, 5, 233–246. 10.1111/1467-7687.00225
- MacKenzie H, Graham SA, & Curtin S (2011). Twelve-month-olds privilege words over other linguistic sounds in an associative learning task. *Developmental Science*, 14, 249–255. [PubMed: 22213898]
- Marcus GF, Fernandes KJ, & Johnson SP (2012). The role of association in early word-learning. *Frontiers in Psychology*, 3: 283. doi:10.3389/fpsyg.2012.00283 [PubMed: 22934086]
- Mervis CB (2009). Language and literacy development of children with Williams syndrome. *Topics in Language Disorders*, 29, 149–169. [PubMed: 22485062]
- Mervis CB, Becerra AM, Pitts CH, & Marchman VA (2019, June). MacArthur-Bates Communicative Development Inventory expressive vocabulary and sentence complexity norms for children with Williams syndrome aged 16 – 48 months. Poster presented at the Symposium on Research in Child Language Disorders, Madison, WI.
- Mervis CB, & Bertrand J (1997). Developmental relations between cognition and language: Evidence from Williams syndrome In Adamson LB & Ronski MA (Eds.), *Communication and language acquisition: Discoveries from atypical development* (pp. 75–106). Baltimore, MD: Brookes.
- Mervis CB, & John AE (2010). Cognitive and behavioral characteristics of children with Williams syndrome: Implications for intervention approaches. *American Journal of Medical Genetics Part C*, 154C, 229–248.
- Mervis CB, & John AE (2012). Precursors to language and early language development in Williams syndrome In Farran EK & Karmiloff-Smith A (Eds.), *Neurodevelopmental disorders across the lifespan: A neuroconstructivist approach* (pp. 187–204). Oxford, England: Oxford University Press.
- Mervis CB, Robinson BF, Bertrand J, Morris CA, Klein-Tasman BP, & Armstrong SC (2000). The Williams Syndrome Cognitive Profile. *Brain and Cognition*, 44, 604–628. doi:10.1006/brcg.2000.1232 [PubMed: 11104544]
- Mullen EM (1995). *Mullen Scales of Early Learning*: Circle Pines, MN: American Guidance Service.
- Nazzi T, & Bertoni J (2003). Before and after the vocabulary spurt: two modes of word acquisition? *Developmental Science*, 6, 136–142.
- Oakes LM (2010). Using habituation of looking time to assess mental processes in infancy. *Journal of Cognition and Development*, 11, 255–268. [PubMed: 20730029]
- Pruden SM, Hirsh-Pasek K, Golinkoff RM, & Hennon EA (2006). The birth of words: Ten-month-olds learn words through perceptual salience. *Child Development*, 77, 266–280. [PubMed: 16611171]
- Slater A, Quinn PC, Brown E, & Hayes R (1999). Intermodal perception at birth: Intersensory redundancy guides newborn infants' learning of arbitrary auditory- visual pairings. *Developmental Science*, 2, 333–338.
- Sloutsky VM, & Robinson CW (2008). The role of words and sounds in infants' visual processing: from overshadowing to attentional tuning. *Cognitive Science*, 32, 342–365. doi:10.1080/03640210701863495 [PubMed: 21635339]
- Thiessen ED, Hill EA, & Saffran JR (2005). Infant-directed speech facilitates word segmentation. *Infancy*, 7, 53–71.
- Thurman AJ, & Mervis CB (2013). The regulatory function of social referencing in preschoolers with Down syndrome or Williams syndrome. *Journal of Neurodevelopmental Disorders*, 5: 2. [PubMed: 23406787]
- Torkildsen JVK, Svangstu JM, Friis Hansen H, Smith L, Simonsen HG, 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, 1266–1282. [PubMed: 18284350]

- Tsui ASM, Byers-Heinlein K, & Fennell CT (2019). Associative word learning in infancy: A meta-analysis of the switch task. *Developmental Psychology*, 55, 934–950. doi:10.1037/dev0000699 [PubMed: 30730174]
- Werker JF, Cohen LB, Lloyd VL, Casasola M, & Stager CL (1998). Acquisition of word-object associations by 14-month-old infants. *Developmental Psychology*, 34, 1289–1309. [PubMed: 9823513]
- Werker JF, Fennell CT, Corcoran KM, & Stager CL (2002). Infants' ability to learn phonetically similar words: Effects of age and vocabulary size. *Infancy*, 3, 1–30.
- Yoshida KA, Fennell CT, Swingley D, & Werker JF (2009). Fourteen-month-old infants learn similar-sounding words. *Developmental Science*, 12, 412–418. doi:10.1111/j.1467-7687.2008.00789.x [PubMed: 19371365]
- Zamuner TS, Fais L, & Werker JF (2014). Infants track word forms in early word-object associations. *Developmental Science*, 17, 481–491. doi:10.1111/desc.12149 [PubMed: 24576138]

Research Highlights

- We tested the universality of the developmental pattern of early associative word learning in typically-developing (TD) infants and infants and toddlers with Williams syndrome (WS).
- For both groups, expressive vocabulary size was related to the development of *early* associative word learning (i.e., using *dissimilar* words in the standard switch task).
- Participants with larger expressive vocabularies formed word-object associations, whereas those with smaller vocabularies attended to the objects and failed to form word-object associations.
- Although early word-object association formation in children with WS is delayed, the developmental pattern is similar to that of TD infants.

	Objects			Words
Set 1	A	B	C	<i>neem</i> <i>lif</i> <i>pok</i>
Set 2	D	E	C	<i>kaz</i> <i>jun</i> <i>geb</i>

Figure 1.
The six objects and six words that were used to create the word-object pairs in stimulus sets 1 and 2

Habituation Phase

“neem”

“lif”

Test Phase

“neem”

“neem”

“pok”

“lif”

Familiar

Switch

Novel Word

Novel Object

Figure 2.

Example stimuli presented during the habituation and test phases. Stimulus set 1 is shown here

Figure 3.

Mean looking time(s) during test trials. Three planned comparisons (familiar vs. switch, novel word, and novel object) were conducted on each population within each EV group ($\alpha = .017$). The patterns of results were similar across the two populations (TD and WS). In the small EV group, neither population formed word-object associations; they processed only the novel object. In the large EV group, participants in both populations processed the words, objects, and the word-object links (as tested with the switch trial). Error bars represent standard errors. * $p < .017$, ** $p < .001$

Expressive Vocabulary and Looking Times During Test Trials in the Total Sample and as a Function of Group

Table 1

Group	n	Age (Months)		Expressive Vocabulary (N of words)			Mean Looking Times on Test Trials (SD)				
		<i>M</i> (SD)	<i>M</i> (SD)	<i>M</i> (SD)	<i>Mdn</i> (IQR)	Range	Familiar	Switch	Novel Word	Novel Object	
TD	Total	59	12.98 (0.88)	13.63 (15.49)	10 (4 – 16)	0 – 90	5.54 (3.15)	7.42 (4.39)	8.02 (5.15)	11.96 (5.13)	
	Small EV	31	12.57 (0.78)	4.71 (3.27)	5 (2 – 8)	0 – 10	5.31 (2.97)	6.57 (3.82)	7.12 (4.32)	10.90 (4.66)	
	Large EV	28	13.43 (0.77)	23.50 (17.63)	16 (14 – 21.75)	12 – 90	5.80 (3.37)	8.36 (4.84)	9.03 (5.86)	13.13 (5.45)	
WS	Total	31	24.57 (6.74)	60.42 (94.87)	13 (1 – 68)	0 – 342	4.62 (2.83)	7.04 (5.05)	10.76 (5.78)	13.93 (4.71)	
	Small EV	13	21.00 (7.06)	2.00 (3.24)	1 (0 – 2.00)	0 – 10	4.49 (2.47)	4.89 (2.28)	9.06 (5.80)	14.00 (5.27)	
	Large EV	18	27.14 (5.31)	102.61 (106.69)	52.5 (19.25 – 188.50)	12 – 342	4.72 (3.13)	8.58 (5.94)	11.99 (5.60)	13.87 (4.43)	