Published in final edited form as:
Scand J Psychol. 2013 February ; 54(1): 20–25. doi:10.1111/sjop.12001.

15-Month-Olds' Transfer of Learning between Touch Screen and Real-World Displays: Language Cues and Cognitive Loads

Elizabeth Zack[1,3], **Peter Gerhardstein**[2], **Andrew N. Meltzoff**[3], and **Rachel Barr**[1]

[1]Georgetown University

[2]Binghamton University-SUNY

[3]University of Washington

Abstract

Infants have difficulty transferring information between 2D and 3D sources. The current study extends Zack et al.'s (2009) touch screen imitation task to examine whether the addition of specific language cues significantly facilitates 15-month-olds' transfer of learning between touch screens and real-world 3D objects. The addition of two kinds of linguistic cues (object label plus verb or nonsense name) did not elevate action imitation significantly above levels observed when such language cues were not used. Language cues hindered infants' performance in the 3D→2D direction of transfer, but only for the object label plus verb condition. The lack of a facilitative effect of language is discussed in terms of competing cognitive loads imposed by conjointly transferring information across dimensions and processing linguistic cues in an action imitation task at this age.

Imitation from television has been documented in infants (e.g., Barr & Hayne, 1999; Barr, Muentener, & Garcia, 2007; McCall, Parke, & Kavanaugh, 1977; Meltzoff, 1988). Nonetheless, transfer of learning from 2-dimensional (2D) sources to real world, 3-dimensional (3D) objects present a significant challenge for infants. It has been widely documented that infants learn less from 2D sources (e.g., television) than from live, face-to-face interactions with real objects and people (e.g., Barr & Hayne, 1999; Meltzoff, Kuhl, Movellan, & Sejnowski, 2009; Simcock & DeLoache, 2006; Zack, Barr, Gerhardstein, Dickerson, & Meltzoff, 2009). In certain situations, language cues have been found to ameliorate the 'transfer deficit' from 2D sources in tasks involving imitative learning during infancy (Barr, 2010; Barr & Wyss, 2008; Seehagen & Herbert, 2010; Simcock & DeLoache, 2006; Simcock, Garrity, & Barr, 2011). For example, Seehagen and Herbert (2010) found that narration enhances 18-month-olds' imitation from television relative to empty labels. In the second year of life infants begin to rapidly map nouns from an infant-directed speech stream to objects (Bloom & Markson, 1998; Booth & Waxman, 2003; Carey & Bartlett, 1978; Kay-Raining Bird & Chapman, 1998; Pruden, Hirsh-Pasek, Golinkoff, & Hennon, 2006). Naming is a way to increase the salience of object properties and object similarities early in development (Waxman, 2008).

Researchers using measures other than imitation have also reported that language cues enhance infant transfer from 2D sources to 3D objects in object identification tasks (e.g., Allen & Scofield, 2010; Ganea, Bloom Pickard, & DeLoache, 2008; Preissler & Carey, 2004; Scofield & Williams, 2009). Ganea et al. (2008), for example, used a forced choice procedure to examine 15- and 18-month-old infants' transfer of object identification

Correspondence concerning this article should be addressed to Dr. Rachel Barr, Department of Psychology, Georgetown University, Washington, DC 20057. rfb5@georgetown.edu.

between 2D picture book images and 3D objects (or vice versa) when a nonsense label (e.g., ‘blicket’) was provided. The infants’ task was to identify which novel object was the ‘blicket’ across the dimensional shift: Infants succeeded at pointing out the ‘blicket’, regardless of transfer direction. Scofield and Williams (2009), using a word-learning object selection task, demonstrated that 2-year-olds are able to learn and extend novel labels (e.g., “This is a fep”) presented on video via voiceover to novel video exemplars that differ in size and color.

One innovation of a recent transfer of learning study from 3D to 2D (and vice versa) was the combination of touch screen technology with a test of action imitation (Zack et al., 2009). This study first established that 15-month-old infants imitate pushing a virtual 2D button after viewing demonstrations on a 2D touch screen image and also imitate pushing a real 3D button following demonstrations on a 3D object. The crucial next test showed that infants pushed a 2D virtual button following demonstrations on a 3D object and vice versa—in other words, infants transferred the learning about actions across dimensions at above-baseline levels, with no differences as a function of the direction of transfer. Importantly, however, infants produced significantly fewer target actions in both cross-dimensional transfer conditions (2D→3D, 3D→2D) in comparison to infants’ performance in both within-dimension (2D→2D, 3D→3D) conditions (which did not differ).

Zack et al. (2009) proposed that poor representational flexibility provides a likely basis for the decrement in performance encountered in the task involving the transfer of information across dimensions. This explanation suggests that infant memory performance is enhanced by the precision of the match between the cues present at the time of encoding and retrieval. A mismatch of cues at the time of retrieval negatively impacts infant performance (Hayne, 2006). A decrease in the matching cues, due to the difference in dimensionality (and the concurrent sensory-perceptual changes caused by this difference), might have reduced infants’ ability to retrieve the representation of the initial display and to transfer the relevant information to another dimension in the Zack et al. (2009) study. Thus, in the present work, we increased the number of available cues by adding specific verbal cues during encoding and retrieval to examine the effect of increasing cues on transfer of learning across 2D↔3D sources.

The present study extended Zack et al.’s (2009) touch screen imitation procedure and added either a nonsense name (e.g., Dax), or object label (e.g., cow) plus verb (i.e., push) in the transfer task (2D→3D, 3D→2D). For the nonsense name conditions, we chose to name the objects / images with a nonsense proper noun (e.g., “This is Dax”) rather than a nonsense count noun (e.g., “This is *a* dax”) because we did not want to confuse children by substituting a novel count noun for a word that they may already know (e.g., cow). To facilitate comparisons across the original Zack et al. work and the current one, we used language that was similar in length to the empty language cues provided during demonstrations in the Zack et al. (2009) study. For example, “Isn’t that fun?” was transformed into “Isn’t Dax fun?” in the current nonsense name condition (for similar rationales see Barr & Wyss, 2008; Ganea et al., 2008; Herbert & Hayne, 2000; Scofield & Williams, 2009). For the object label + verb condition, we used the appropriate count noun to label the object (e.g., cow) and did not embed the object label or verb in a sentence to make the cue as simple as possible. Herbert (2011) found that providing a label (i.e., “Look a puppet”) coupled with words for the actions (i.e., “Off. Shake. On.”) increased 12- and 15-month-olds’ imitation on a 3D→3D generalization task compared to when empty language cues were provided during demonstration (e.g., “Did you see that?”) and test (i.e., “Here he is”). Thus, in the current study, in addition to using an English word (e.g., “cow”) to label the object, the experimenter said the word “push” during the demonstration to draw attention to the target action itself (Baldwin & Markman, 1989; Childers & Tomasello, 2006; Golinkoff & Hirsh-Pasek, 2006).

Prior research using multiple paradigms suggests that infants are successful in extracting and mapping linguistic labels early in the second year of life (e.g., Barr & Wyss, 2008; Ganea et al., 2008; Herbert, 2011; Herbert & Hayne, 2000; Kay-Raining Bird & Chapman, 1998; Pruden et al., 2006; Simcock et al., 2011; Waxman, 2008). The addition of specific linguistic cues (nonsense names, object labels, verbs) might, therefore, facilitate transfer of action imitation across dimension. However, Herbert and Hayne (2000) found that nonsense language cues did not aid 18-month-olds' imitation when 3D objects were perceptually different (e.g., different color, but functionally equivalent) following a 24-hour delay between demonstration and test. Importantly, transfer of an observed action from a real object to a touch screen and vice versa presents an additional cognitive challenge not involved in typical tests of language comprehension – acting on a 2D representation and 3D object in the same way, treating them as functionally equivalent as measured by the actions taken on them. It therefore remains an open question as to whether linguistic cues would assist in a touch screen task using action imitation as a response measure, and if so, which linguistic cues would be of most assistance.

Method

Participants

The participants were 71 (30 male) 15- to 16-month-old (M = 15 months, 17 days, SD = 15.8) full-term healthy infants. Infants and their parents were recruited through commercially available records, childcare centers, and by word of mouth in the *metro area. Participants were Caucasian (n = 61), Latino (n = 3), African-American (n = 2), Asian (n = 1), and of mixed race/ethnicity (n = 4). The majority of infants were from middle- to upper-class families (SES M = 78.7, SD = 13.8, 93% reporting), using the criteria advanced by Nakao and Treas (1992), and highly educated (M = 17.6 years, SD = 1.1, 98.6% reporting). Six additional infants were excluded from the final sample due to equipment failure (n = 2), experimenter error (n = 1), or failure to touch the stimuli during the test phase (n = 3).

Design

Infants were randomly assigned to one of six groups: *nonsense name 2D demo→3D test* (n = 12), *nonsense name 3D demo→2D test* (n = 12), *object label + verb 2D demo→3D test* (n = 16), *object label + verb 3D demo→2D test* (n = 17), *3D baseline control* (n = 7), and *2D baseline control* (n = 7). The *3D baseline control* and *2D baseline control* groups were used to assess the spontaneous production of the target actions in the absence of the demonstration.

Using a partial replication approach, pooled *3D baseline* and pooled *2D baseline* groups were created by including 10 additional, age-matched, baseline control infants (5 infants in each group) that used the same stimuli and experimental procedures as in the original touch screen study (Zack et al., 2009). These infants did not see a demonstration of the target actions prior to the test. There was no difference between the baseline scores of the current baseline groups and the previously collected baseline data $t(20) = 1.31$, $p = .21$; therefore these data were collapsed for subsequent analyses.

We also conducted a cross-experiment comparison, using data from the transfer dimension (2D→3D, 3D→2D) empty language cue conditions published in Zack et al. (2009). Twenty-four additional 15-month-old infants (12 infants in each transfer dimension group) were included in the cross-experiment analysis (reproduced with permission from *British Journal of Developmental Psychology* © The British Psychological Society 2009).

Participants were recruited by the same laboratory in the same location for the present study and by Zack et al.

Apparatus, Experimental Set-up, and Procedure

The non-commercially available stimuli, experimental set-up, and procedure were identical to those reported in Zack et al. (2009) for the transfer dimension (2D→3D, 3D→2D) conditions, except that the language cues provided were different. Zack et al. (2009) created 3D objects (e.g., bus, fire truck, cow, and duck) out of button boxes and depicted an image of those objects on a touch screen (see Figure 1). Pressing a "virtual button" on the touch screen image produced the same sound as pressing a real button on the 3D object: the cow mooed, the duck quacked, the bus honked, and the fire truck produced a siren. Infants were visited in their homes; every child saw one vehicle and one animal stimulus (e.g., bus/cow) and order was counterbalanced across stimuli. The 3D object or 2D touch screen was placed on a lap table (61 wide × 32 tall × 37.5 cm deep) on the floor; this table was used as the demonstration and test surface for all conditions (see Figure 1). Children sat on a child-sized step stool or their caregiver's lap.

Demonstration period—The experimenter demonstrated the target action six times in succession for each stimulus by extending the index finger and reaching across the front of the stimulus to push a real button on a 3D object or a virtual button on a 2D touch screen to produce a sound (e.g., pushing the real or virtual button on the cow produced a mooing sound). For the nonsense name conditions, the experimenter provided the word "Dax" or "Modi" (e.g., "This is my friend Dax"; see Table 1) before performing the target action. The nonsense label phrases were delivered in the same order for all infants. The labels "Dax" and "Modi" were counterbalanced across stimuli. For the object label + verb conditions, the experimenter labeled each stimulus with the appropriate English word (i.e., cow, duck, fire truck, or bus) at the beginning of each demonstration. In addition, the experimenter said the word "push" just before pressing the button during each demonstration. The demonstration period was on average 34.53 s ($SD = 3.35$) per stimulus for the 3D objects and 36.13 s ($SD = 4.08$) per stimulus for the 2D touch screen images. Small variations in the demonstration times were due to occasional interruptions in the household (e.g., dog barking), technical problems on the touch screen, or infant fussiness. Infants in the baseline control groups did not participate in the demonstration phase. Rather, they were shown the test stimuli for the first time during the test phase.

Test period—The test period was identical to Zack et al. (2009) except that the experimenter prompted infants in the transfer conditions. In the nonsense name condition, the experimenter said the phrase, "Here is my friend Dax again. Can you show me how Dax works?" (see Table 1). In the object label + verb condition, the experimenter only provided the object label (e.g., bus) at the beginning of the test period. In the baseline control condition, the experimenter said, "Now it's your turn". Infants were given 30 s from time of first touch of the 3D object or 2D touch screen to imitate the target action on each stimulus. Stimuli were presented in the same order as during the demonstration for the experimental transfer groups.

Scoring—For each test trial, a primary coder scored if the infant pressed the button within 30 s from the time of first touch (score = 1) or not (score = 0). We created an *imitation score* by averaging across the two stimuli to yield a single averaged score (range of 0–1). A secondary coder scored 55% of the sessions; interobserver reliability was 96% ($\kappa = .90$).

Language inventory—Caregivers ($n = 70$) completed the infant short-form version of the MacArthur Communicative Development Inventory (CDI) Level I, an 89-word checklist of words their infant understands and understands and says (Fenson et al., 2000). Infants' percentile rank for receptive language ability was within expected norms for the 15- to 16-month-old age range (M = 46.2, SD = 28.16). In addition, 46% of infants tested with the bus, 53% tested with the fire truck, 59% tested with the cow, and 43% tested with the duck were reported to understand the corresponding word. Only 33% of infants (n = 11) tested in the object label + verb conditions were reported to have the word "push" in their receptive vocabulary.

Results

Preliminary analyses revealed that infant sex, test stimuli, and nonsense name type (i.e., Dax or Modi) did not produce any significant main effects or enter into any interactions. Infants' percentile rank for receptive vocabulary, as measured by the CDI, was not significantly related to infant transfer performance. These variables were therefore collapsed across all subsequent analyses.

An initial examination of the mean baseline imitation scores showed a different pattern of results for the 2D test (M = .21) and 3D test (M = .04) conditions. Therefore, we created difference scores to equate for the higher mean in the 2D test baseline group (cf., Brito, Barr, McIntyre, & Simcock, 2011 for a similar approach). A difference score was calculated for each participant by subtracting the mean of the corresponding test dimension baseline from each participant's imitation score. Thus, baseline levels were incorporated into the difference scores, which enabled us to make direct comparisons across the specific and empty language cue groups.

The primary goal of the study was to examine the effect of the presence of specific language cues on infants' imitation during the response period (test), relative to infants' transfer during the response period in the absence of specific language cues. We compared the difference scores from the specific language cue conditions in the current study with the difference scores from the empty language cue transfer conditions reported by Zack et al. (2009), who used the identical apparatus and age of participants. This cross-experiment analysis allowed us to examine whether the infants in the current test of specific language cues (nonsense name, object label + verb) performed better than infants who only heard empty language ("Isn't that fun?") as reported in Zack et al. (2009). A one-way ANOVA using the six groups (2D→3D nonsense name, 3D→2D nonsense name, 2D→3D object label + verb, 3D→2D object label + verb, 2D→3D empty language, 3D→2D empty language) revealed a main effect of condition, $F(5, 75) = 2.83$, $p = .02$. Post-hoc Tukey tests revealed that the 3D→2D object label + verb group performed significantly worse than the 2D→3D object label + verb and 2D→3D empty language cue groups (see Table 2). No group given a specific language cue performed significantly better than the empty language cue groups: Overall, the addition of an object label plus verb or a nonsense name during demonstration and test did not facilitate transfer performance above that of empty language cues.

Additional chi-square analyses examined whether infants whose receptive vocabulary contained the specific object label used in the study (e.g., cow) were more likely to show successful imitative transfer for that specific object/image during test. There was no relationship between infant's comprehension of the object label and transfer success for the 3D specific language cue groups, $\chi^2(1, N = 54) = .00$, $p = 1.0$, or for the 2D specific language cue groups, $\chi^2(1, N = 58) = 0.48$, $p = .49$. Fisher's exact tests also revealed that there was no relationship between infant's comprehension of the verb "push" and transfer success in the object label + verb 3D test (p = 1.0) or 2D test (p = .28) conditions.

Discussion

We examined whether the addition of specific language cues would significantly boost imitation in the transfer conditions (2D→3D, 3D→2D) above that reported in Zack et al. (2009). The addition of a object label + verb or a nonsense name did not facilitate infant transfer above the performance levels reported for the empty language cue conditions in Zack et al. (2009) in either transfer direction. Infants remained far from reaching the within-dimension imitation performance (2D→2D, 3D→3D) found by Zack et al. (2009). Furthermore, examination of infant CDI receptive vocabulary measures showed that even those infants who understood the object labels or infants with higher receptive language ability did not show increased ability to transfer across dimension at this age (of course, this does not preclude such a language effect at older ages).

The findings also revealed a difference in infant transfer performance based on the direction of transfer and type of language cue provided in the current study. Infants exhibited similar levels of transfer across the specific and empty language cue conditions, except for the 3D→2D object label + verb condition. The addition of the object label plus verb hindered infants' performance in one direction (3D→2D) but not the other (2D→3D). We do not have a ready explanation for this particular effect. One possibility is that the mismatch in verbal cues provided during demonstration and test (i.e., the experimenter only said "push" during the demonstration) coupled with being tested with a contextually less familiar stimulus (i.e., the touch screen) was confusing to some infants. Infants might have assumed that the novel 2D touch screen did not work in the same way in the absence of the verbal action prompt. In the nonsense name conditions, however, infants heard the action prompt "Can you show me how Dax works?", perhaps suggesting that the touch screen could be acted upon. The original touch screen test (Zack et al., 2009) contained no such mismatch in verbal cues between demonstration and test and found no difference in transfer between dimensions as a function of direction. This finding and line of reasoning requires additional empirical investigation.

Overall, these results were somewhat surprising. Labeling has been found to facilitate categorization, inductive inference, imitation, and generalization in infants as young as 12 months (e.g., Booth & Waxman, 2002, 2003; Graham, Kilbreath, & Welder, 2004; Waxman, 2008; Waxman & Lidz, 2006), so why did these language cues not facilitate transfer on the touch screen action imitation task? One possibility is that the specific language cues created an additional cognitive load in an already difficult representational task, that is, at best language cues failed to facilitate transfer and at worst may have interfered with transfer. For example, Barr, Shuck, Salerno, Atkinson, and Linebarger (2010) argued that the addition of background music created additional cognitive load, thereby disrupting 6- to 18-month-old infants' ability to encode actions presented in a video demonstration. Similarly, cognitive overload may have also been intensified by the addition of specific language cues in the current study, requiring additional processing over and above understanding the 2D stimulus and representing the actions demonstrated. Other theorists have argued there is a high demand on cognitive resources during symbol use (DeLoache, 1991, 1995) and a high demand on cognitive resources to process language cues at this age (e.g., Fernald, McRoberts, & Swingley, 2001). In the present study, the language cues might not have improved infant transfer because infants were asked to use a symbol (language) in conjunction with another symbol (2D image) using a novel 2D touch screen interface that they most likely had not encountered before.

An alternate explanation is that linguistic processing was taxed by both language cue conditions but in different ways. The nonsense name "Dax" was embedded in a complex phrase and its placement within the phrase varied (first, middle, or final position) across demonstrations. Word placement can influence 15-month-olds' ability to recognize a word (Fernald et al., 2001). Presenting the novel proper noun at alternating parts of the sentence, for example, might be more taxing to young infants because they need to ignore the other auditory information while also mapping the word to the referent at different time points (Plunkett, 2006). Thus, our phrases using the nonsense names may have been too complex to aid transfer and boost performance significantly above that found in the original Zack et al., (2009) paper.

On the other hand, the language cues presented in the object label plus verb conditions did not contain articles; rather the object labels and verb were presented in isolation. It is possible that the omission of the article before the noun removed a cue that infants of this age need. Prior research suggests that the inclusion of an article plus count noun enhances generalization in 3D→3D tasks relative to empty labels (Herbert, 2011) or an object label presented in isolation (Keates & Graham, 2008) for infants between 12 and 16 months of age. Findings from a recent study examining transfer from 2D to 3D (Keates, Graham, & Ganea, 2010), however, suggest that the absence of a count noun is probably not the sole explanation for why infants in the touch screen transfer task failed to exploit the verbal cues. Keates et al. (2010) found that marking a novel label as a count noun within a phrase (e.g., "This is a blicket" rather than "blicket") did not enhance 18-month-olds' transfer of learning from a target action depicted in a picture book to a corresponding real-world, 3D object. This finding is consistent with the results of the present study in which a static image was presented on a touch screen.

At first glance, the Keates et al. (2010) and present findings appear to be inconsistent with those of Ganea et al. (2008), who found that 15- and 18-month-olds successfully used shared nonsense count nouns to transfer between novel picture book images and their real-world referents. However, there are two important points to note about the Ganea et al. study. First, the 15-month-olds experienced difficulty with the task, and the authors had to adapt the procedure by removing the images from the book to facilitate transfer. Second, the infants' task in Ganea et al. was simply to point to the corresponding object or image, and not to manipulate it or demonstrate that it functions in the same way. We would argue that pointing to a corresponding object or image is a less demanding task than demonstrating its functional equivalence.

Although naming the object or providing a simple label of the object and action were not facilitative in the present study with 15-month-old infants, researchers have shown that providing a meaningful narration (including both object labels and a description of the events) during encoding help older infants and young children in cross-dimension generalization tasks (e.g., Seehagen & Herbert, 2010; Simcock & DeLoache, 2006; Simcock et al., 2011). Further empirical investigation is needed to examine whether the addition of narration and other types of language cues will facilitate transfer on the touch screen task at different ages.

One limitation in this study is that infants' performance in the 2D baseline condition was relatively high compared to infants' performance in the 3D baseline condition. This difference prompted us to analyze the data using difference scores so that infants' transfer performance was considered relative to the average baseline score for their corresponding test dimension. There are a couple potential explanations for the difference in infants' baseline performance. First, the higher 2D baseline found in this study is largely attributable to the response of one child who pushed the virtual button on the 2D image for both stimuli. Second, pushing the virtual button on a touch screen requires a less specific motor action than pushing the real button on the 3D object; the virtual button might be more easily triggered by a child who touches the screen a lot compared to exploration of the 3D object.

Taken together, the findings from this study suggest that the relationship between processing language cues and learning the functionality of a 2D image and its correspondence to a 3D object might have taxed infants' already fragile representational system (Barr, 2010; DeLoache, 1991; Fernald et al., 2001). Interestingly, developmental cognitive neuroscience research has demonstrated that infants have different event-related potential (ERP) responses to real-world objects and 2D representations of them—the neural signature for recognition of familiar versus novel objects (e.g., a favorite toy) occurs significantly faster when the objects are presented in 3D than when presented in 2D (Carver, Meltzoff, & Dawson, 2006). This provides converging support for the idea that there is an added task difficulty involved in mapping from 3D objects to their corresponding 2D representations (the cross-dimension transfer problem). Infants are also novice language learners, and as such, might not be able to flexibly apply verbal cues when they are paired with a demanding perceptual-cognitive transfer task. Further research should be directed to examining transfer of learning between real-world objects and 2D representations to determine why it might be difficult for young children to transfer learning on tasks requiring them to understand the functional equivalence between 3D and 2D and to act appropriately. The touch screen paradigm provides a good method for examining representational flexibility in young infants on a task that involves transferring of action across dimensions.

Acknowledgments

This research was supported by a Fellowship to Elizabeth Zack from the American Psychological Foundation; NSF Grants to Peter Gerhardstein and Rachel Barr (1023772), Sandra Calvert (0126014), and Andrew Meltzoff (SBE-0354453); NIH Grant to Andrew Meltzoff (HD-22514); and the Georgetown University Graduate School of Arts and Sciences. Authors would like to thank the families for their participation and members of the Georgetown Early Learning Project for their help in data collection and coding.

References

Allen R, Scofield J. Word learning from videos: more evidence from 2-year-olds. Infant and Child Development. 2010; 19:649–661.

Baldwin DA, Markman EM. Establishing word-object relations: A first step. Child Development. 1989; 60:381–396. [PubMed: 2924658]

Barr R. Transfer of learning between 2D and 3D sources during infancy: Informing theory and practice. Developmental Review. 2010; 30:128–154. [PubMed: 20563302]

Barr R, Hayne H. Developmental changes in imitation from television during infancy. Child Development. 1999; 70:1067–1081. [PubMed: 10546335]

Barr R, Muentener P, Garcia A. Age-related changes in deferred imitation from television by 6- to 18-month-olds. Developmental Science. 2007; 10:910–921. [PubMed: 17973804]

Barr R, Shuck L, Salerno K, Atkinson E, Linebarger D. Music interferes with learning from television during infancy. Infant and Child Development. 2010; 19:313–331.

Barr R, Wyss N. Reenactment of televised content by 2-year-olds: Toddlers use language learned from television to solve a difficult imitation problem. Infant Behavior and Development. 2008; 31:696–703. [PubMed: 18514319]

Bloom P, Markson L. Intention and analogy in children's naming of pictorial representations. Psychological Science. 1998; 9:200–204.

Booth AE, Waxman SR. Object names and object functions serve as cues to categories for infants. Developmental Psychology. 2002; 38:948–957. [PubMed: 12428706]

Booth AE, Waxman SR. Mapping words to the world in infancy: Infants' expectations for count nouns and adjectives. Journal of Cognition and Development. 2003; 4:357–381.

Brito N, Barr R, McIntyre P, Simcock G. Picture this: Long-term retention from books and video during toddlerhood. Journal of Experimental Child Psychology. 2011 Advance online publication.

Carey S, Bartlett E. Acquiring a single new word. Papers and Reports on Child Language Development. 1978; 15:17–29.

Carver LJ, Meltzoff AN, Dawson G. Event-related potential (ERP) indices of infants' recognition of familiar and unfamiliar objects in 2- and 3-dimensions. Developmental Science. 2006; 9:51–62. [PubMed: 16445396]

Childers, JB.; Tomasello, M. Are nouns easier to learn than verbs? Three experimental studies. In: Hirsh-Pasek, K.; Golinkoff, RM., editors. Action meets word: How children learn verbs. New York: Oxford University Press; 2006. p. 311-335.

DeLoache JS. Symbolic functioning in very young children: Understanding of pictures and models. Child Development. 1991; 62:736–752. [PubMed: 1718666]

DeLoache JS. Early understanding and use of symbols: The model model. Current Directions in Psychological Science. 1995; 4:109–113.

Fenson L, Pethick S, Renda C, Cox JL, Dale PS, Reznick JS. Short-form versions of the MacArthur Communicative Development Inventories. Applied Psycholinguistics. 2000; 21:95–116.

Fernald, A.; McRoberts, GW.; Swingley, D. Infants' developing competence in recognizing and understanding words in fluent speech. In: Weissenborn, J.; Höhle, B., editors. Approaches to bootstrapping: Phonological, lexical, syntactic and neurophysiological aspects of early language acquisition. Vol. Volume 1. Amsterdam: John Benjamins; 2001. p. 97-123.

Ganea PA, Bloom Pickard M, DeLoache JS. Transfer between picture books and the real world by very young children. Journal of Cognition and Development. 2008; 9:46–66.

Golinkoff, RM.; Hirsh-Pasek, K. Introduction: Progress on the verb learning front. In: Hirsh-Pasek, K.; Golinkoff, RM., editors. Action meets word: How children learn verbs. New York: Oxford University Press; 2006. p. 3-28.

Graham SA, Kilbreath CS, Welder AN. Thirteen-month-olds rely on shared labels and shape similarity for inductive inferences. Child Development. 2004; 75:409–427. [PubMed: 15056196]

Hayne, H. Age-related changes in infant memory retrieval: Implications for knowledge acquisition. In: Munakata, Y.; Johnson, MH., editors. Processes of brain and cognitive development. Attention and performance XXI. Oxford: Oxford University Press; 2006. p. 209-231.

Herbert JS. The effect of language cues on infants' representational flexibility in a deferred imitation task. Infant Behavior & Development. 2011; 34:632–635. [PubMed: 21798600]

Herbert J, Hayne H. Memory retrieval by 18—30-month-olds: Age-related changes in representational flexibility. Developmental Psychology. 2000; 36:473–484. [PubMed: 10902699]

Kay-Raining Bird E, Chapman RS. Partial representations and phonological selectivity in the comprehension of 13- to 16-month-olds. First Language. 1998; 18:105–127.

Keates J, Graham SA. Category markers or attributes: Why do labels guide infants' inductive inferences? Psychological Science. 2008; 19:1287–1293. [PubMed: 19121139]

Keates, J.; Graham, S.; Ganea, P. From picture books to the real world: Infants generalization of nonobvious object properties. Baltimore, MD: Poster session presented at the International Conference on Infant Studies; 2010 Mar.

McCall RB, Parke RD, Kavanaugh RD. Imitation of live and televised models by children one to three years of age. Monographs of the Society for Research in Child Development. 1977; 42

Meltzoff AN. Imitation of televised models by infants. Child Development. 1988; 59:1221–1229. [PubMed: 3168638]

Meltzoff AN, Kuhl PK, Movellan J, Sejnowski TJ. Foundations for a new science of learning. Science. 2009; 325:284–288. [PubMed: 19608908]

Nakao, K.; Treas, J. The 1989 socioeconomic index of occupations: Construction from the 1989 occupational prestige scores. Chicago, IL: National Opinion Research Center; 1992.

Plunkett, K. Learning how to be flexible with words. In: Munakata, Y.; Johnson, MH., editors. Processes of brain and cognitive development. Attention and performance XXI. Oxford, England: Oxford University Press; 2006. p. 233-248.

Preissler MA, Carey S. Do both pictures and words function as symbols for 18- and 24-month-old children? Journal of Cognition and Development. 2004; 5:185–212.

Pruden SM, Hirsh-Pasek K, Golinkoff R, Hennon EA. The birth of words: Ten-month-olds learn words through perceptual salience. Child Development. 2006; 77:266–280. [PubMed: 16611171]

Scofield J, Williams A. Do 2-year-olds disambiguate and extend words learned from video? First Language. 2009; 29:228–240.

Seehagen S, Herbert JS. The role of demonstrator familiarity and language cues on infant imitation from television. Infant Behavior and Development. 2010; 33:168–175. [PubMed: 20137815]

Simcock G, DeLoache JS. The effects of iconicity on re-enactment from picture books by 18- to 30-month-old children. Developmental Psychology. 2006; 42:1352–1357. [PubMed: 17087568]

Simcock G, Garrity K, Barr R. The effect of narrative cues on infants' imitation from television and picture books. Child Development. 2011; 82:1607–1619. [PubMed: 21883157]

Waxman, SR. All in good time: How do infants discover distinct types of words and map them to distinct kinds of meaning?. In: Colombo, J.; McCardle, P.; Freund, L., editors. Infant pathways to language: Methods, models, and research directions. Mahwah, NJ: Lawrence Erlbaum Associates; 2008.

Waxman, SR.; Lidz, J. Early word learning. In: Kuhn, D.; Siegler, R., editors. Handbook of child psychology: Vol. 2. Cognition, perception, and language. 6th ed.. Hoboken, NJ: Wiley; 2006. p. 299-335.

Zack E, Barr R, Gerhardstein P, Dickerson K, Meltzoff AN. Infant imitation from television using novel touch screen technology. British Journal of Developmental Psychology. 2009; 27:13–26. [PubMed: 19972660]

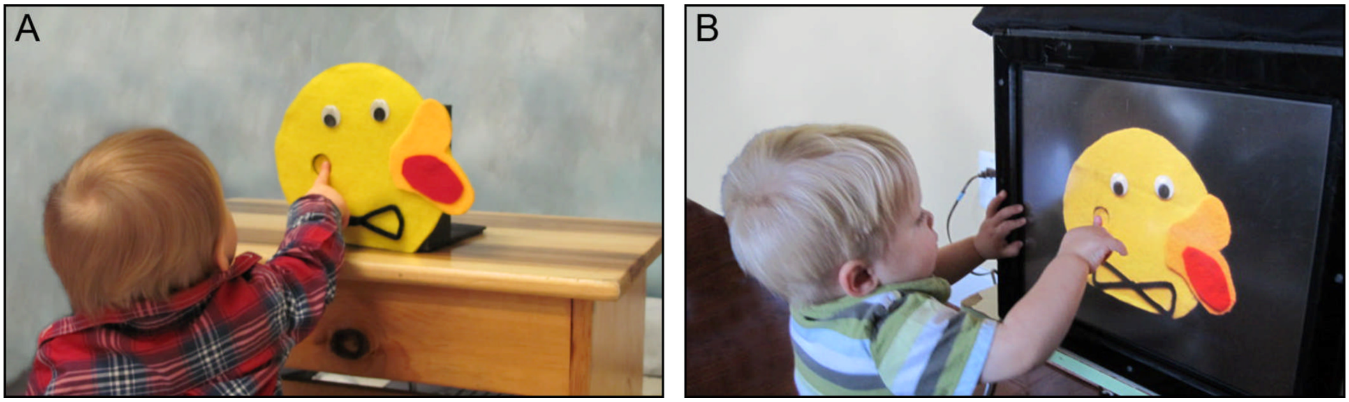

Figure 1.
Example of an infant producing the correct target action on (A) the real 3D duck button box and (B) the 2D duck image depicted on the touch screen. The touch screen image for all stimuli was equated in size to the real 3D object.

Table 1

Nonsense Name Phrases Provided during the Demonstration and Test Periods for the Transfer (2D→3D, 3D→2D) Conditions

Demonstration (Dax)	Test (Dax)
This is my friend DAX	Look, here's my friend DAX again
Isn't DAX fun?	Can you show me how DAX works?
Let's see how DAX works	
What did DAX do?	
DAX is a nice toy	
One more time with DAX	

Note. The word “Modi” was substituted for “Dax” during the demonstration and test periods for the second stimulus.

Table 2

Mean Difference Scores for Language Cue Conditions as a Function of Test Stimulus Dimension

	2D Test			3D Test		
Condition	***n***	**M_{diff} (*SD*)**	**95% CI**	***n***	**M_{diff} (*SD*)**	**95% CI**
Nonsense name	12	.25 (.45)	[−.04, .54]	12	.25 (.33)	[.04, .46]
Object label plus verb	17	−.06 $(.23)_a$	[−.18, .06]	16	.30 $(.35)_b$	[.11, .49]
Empty language	12	.21 (.33)	[.00, .42]	12	.33 $(.31)_b$	[.14, .53]

Note. CI = confidence interval. Data reported for the Empty language cue condition is from Zack et al. (2009). Mean difference scores with different subscripts are significantly different from each other.