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Infants Learn Baby Signs From Video

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There is little evidence that infants learn from infant-oriented educational videos and television programming. This 4-week longitudinal experiment investigated 15-month-olds' (N = 92) ability to learn American Sign Language signs (e.g., patting head for hat) from at-home viewing of instructional video, either with or without parent support, compared to traditional parent instruction and a no-exposure control condition. Forced-choice, elicited production, and parent report measures indicate learning across all three exposure conditions, with a trend toward more robust learning in the parent support conditions, regardless of medium. There were no differences between experimental and control conditions in the acquisition of corresponding verbal labels. This constitutes the first experimental evidence of infants' ability to learn expressive communication from commercially available educational videos.

High-quality educational television programming can be an effective source of learning in preschool- and school-aged children (e.g., Anderson, Huston, Schmitt, Linebarger, & Wright, 2001; Naigles & Mayeux, 2001; Rice, Huston, Truglio, & Wright, 1990). However, evidence supporting *infants'* learning from purportedly educational videos is more equivocal. Several studies suggest a negative correlation between overall media exposure and measures of communicative development in infants under the age of 2 (Chonchaiya & Pruksananonda, 2008; Linebarger & Walker, 2005; Zimmerman, Christakis, & Meltzoff, 2007a), leading the American Academy of Pediatrics [AAP] (2011) to renew its original recommendation (AAP, 1999) to avoid exposing children under 2 to television. Despite this recommendation, an estimated 90% of parents show television and videos to their infants (Zimmerman, Christakis, & Meltzoff, 2007b) including many "educational" videos targeting infants. Videos purporting to promote infants' vocabulary and communicative development, in particular, have saturated the market (Vaala et al., 2010).

Few studies support the notion that educational videos can facilitate language acquisition in infancy. There is limited evidence that repeated exposure via video augments infants' acquisition of words also heard in routine input, relative to infants who encounter the words in routine input alone (Lemish & Rice, 1986; Vandewater, 2011). Vandewater, Barr, Park, and Lee (2010) have also found that repeatedly pairing words and shapes over a period of 15 days enables toddlers as young as 18 months to identify which shapes correspond to particular words.

There is, however, strong evidence that even when infants learn from video, there is a "video deficit" (Anderson & Pempek, 2005; Schmitt & Anderson, 2002)—attenuated learning relative to learning from live, interactive instruction (e.g., Barr & Hayne, 1999; Krcmar, Grela, & Lin, 2007). Furthermore, numerous studies report a failure to exhibit heightened learning of words introduced through a video medium in children younger than 24 months (see DeLoache et al., 2010; Krcmar, 2011; Robb, Richert, & Wartella, 2009).

This debate also extends to whether parental involvement in the viewing experience enhances learning. There is compelling evidence that parent coviewing enhances learning from television in preschoolers (e.g., Reiser, Williamson, & Suzuki, 1988; Roseberry, Hirsh-Pasek, Parish-Morris, & Golinkoff, 2009; Singer & Singer, 1998) and increases attention and verbal interactions during viewing in infants

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(Barr, Zack, Muentener, & Garcia, 2008; Fender, Richert, Robb, & Wartella, 2010; Fidler, Zack, & Barr, 2010; Lemish, 1987). These consequences of parent coviewing may enhance the depth of infants' cognitive processing of the video stimuli (Strouse, O'Doherty, & Troseth, 2013; Strouse & Troseth, 2014). However, recent longitudinal experimental studies (DeLoache et al., 2010; Robb et al., 2009) reported no evidence of heightened word learning in an infant coviewing condition, relative to viewing alone or controls. Despite this lack of evidence that parent coviewing augments learning from television in infants, the AAP (2011) revised its guidelines to suggest that if infant viewing is inevitable, coviewing is better than allowing an infant to view alone.

Although previous longitudinal studies of infants' learning from videos have reported null effects, those studies focused exclusively on the acquisition of high-frequency words to which infants are exposed regularly outside of the video-viewing environment. Because exposure to the target stimuli was not fully controlled, there was evidence of word learning across conditions, including control conditions (e.g., DeLoache et al., 2010; Robb et al., 2009).

In the current longitudinal experiment, we asked whether better controlled exposure delivered exclusively through video would lead to any evidence of learning relative to a no-exposure control condition, and if so whether there was evidence of a video deficit, a benefit for parental coviewing, or both. To ensure experimental control of exposure, we investigated infants' ability to learn symbolic gestures, or *baby signs* instead of focusing on word learning. Baby signs also offer better experimental control of exposure because they are not routinely employed in everyday interactions with infants. Thus, by using signs in place of spoken words, we are able to assess the independent impact of video exposure on learning more directly. Baby signs are a strong test case because infants begin using words and signs at around the same time, shortly after their first birthdays (see Acredolo & Goodwyn, 1988) and appear to use them for the same communicative purposes (Namy, 2001; Namy & Waxman, 1998). The availability of numerous educational videos marketed toward infants that offer sign instruction enables us to systematically and ecologically investigate the impact of medium (video vs. traditional instruction) and parental involvement (coviewing vs. alone) on infant learning.

We investigated 15-month-olds' learning of baby signs from at-home viewing of commercially available videos over the course of 3 weeks of exposure and also tested retention following 1 week without exposure. Acquisition of baby signs when viewing the videos alone or coviewing with parents was compared to traditional parent instruction and to a no-exposure control condition.

Method

Participants

Ninety-two 15-month-olds (M = 15.17 months at study onset, range = 13.95–16.81, SD = 7.04; 51 males) were recruited from the greater Atlanta area. The sample included approximately 74% Caucasian, 18% African American, 1% Asian, 1% Native Hawaiian or Other Pacific Islander, and 6% Mixed Ethnicities, with 8% identifying as being of Hispanic or Latino descent.

Inclusion criteria included exposure to videos or screen media prior to recruitment contact, and lack of prior exposure to "baby signs." Previous exposure to screen media was required to avoid inducing parents who were not already doing so to violate the AAP's recommendation. No parents contacted were excluded for this criterion. Parents' informed consent included acknowledgment of the AAP's recommendation to avoid television exposure for infants under the age of 2.

Stimuli

We identified 18 target signs to use in the experiment. We selected only target signs that were object names to accommodate the use of still photographs of referents in learning assessments, and to mirror the types of labels (both verbal and gestural) most frequently acquired at this age. Target signs were selected based on familiarity of their referents as indexed by age of comprehension of their verbal labels (comprehended at a threshold of 50% of infants by M = 12.3 months; Fenson et al., 1994). These items included: airplane, apple, baby, ball, banana, bear, bird, book, car, cat, cookie, cracker, dog, fish, flower, hat, juice, and shoe. All referents were depicted in at least three different commercially available video productions intended to teach baby sign to infants.

Participants assigned to video-viewing conditions received a DVD compilation derived from six commercially available videos intended to teach infants baby signs. Each compilation included three chapters approximately 20 min in length with footage sampled from three to five videos in each chapter.

Each chapter included clips depicting the signs (and accompanying verbal labels) for each of the 18 objects. Parents were directed to rotate through the chapters across viewings to vary the order in which exposure to the signs occurred. We have opted not to identify the titles of the videos, as we did not seek to test the efficacy of individual video productions. We were interested in assessing the impact of exposure to varying range of commercially available videos. By declining to identify the video productions employed, we avoid any potential opportunities for the products' marketers to make claims that may or may not be warranted based on this composite evidence.

There was variability in the formal features employed across the videos. These included (a) how each sign was introduced (e.g., introduction of sign occurs while an image of the referent was present vs. sequential presentation of the sign and the referent), (b) whether foreground or background music was employed, (c) whether still or moving images of the referents were presented, (d) how many scene changes were involved for each sign (ranging from 6 to approximately 21), and (e) the number of times the sign was repeated (ranging from approximately 3 to 15).

Although these formal features varied across productions, there were also several common factors across all sampled videos. Each video introduced signs in the first or second scene by showing an engaging person (either adult or child) producing a sign while simultaneously speaking the English verbal label for the referent. This introduction of the sign was consistently followed by several images of the referent, followed by a repetition of the sign and verbal label. For example, the video might depict an adult producing a sign for "dog" while saying "dog." This would be followed by images of various types of dogs (real and toy dogs, still and moving pictures). Each clip concluded with the adult or child once again saying and signing "dog."

Parents in the parent instruction condition introduced their infants to the 18 signs using a laboratory-designed picture book in lieu of a video. Each page in the book was dedicated to one target sign (for a total of 18 pages) and included three different still photographs for each target. The stills were taken directly from screen shots included on the videos. A thumbnail picture of an adult producing the target sign with arrows signaling directions of motion was included in the top corner of each page to remind parents how to produce the sign. Appendix S1 in the online Supporting Information depicts sample pages from the book.

Each parent in the parental instruction condition also received a set of printed instructional materials on sign production including still frames from the sign videos demonstrating the sign being performed and pictures of the referents being labeled. These still photographs were augmented by separate printed verbal instructions describing how to perform each sign. The experimenter also demonstrated the signs to the parents in person during their baseline visit to the laboratory.

Procedure

Infants were randomly assigned to one of four conditions: video viewing alone (n = 20), video coviewing with a parent (n = 27), a parent instruction condition that involved teaching signs using a picture book (n = 21), and a no-sign-exposure control condition (n = 24). Seven additional infants who dropped out after 1 or 2 weeks were excluded from the study analysis (two each in video alone, parent instruction, and control group; one in the video coviewing group). In all three experimental groups, parents were instructed to expose infants to 15–20 min of sign instruction at home 4 days a week for 3 weeks, with no exposure to signs between instructional sessions. Given that the children tend to acquire the verbal labels for the 18 objects early in development, we expected children in all conditions to exhibit learning of the verbal labels for these objects due to routine, incidental exposure. As a result, we did not necessarily expect condition effects in word learning, despite the enhanced exposure to both words and signs for these referents resulting from participation in the study.

Video Viewing Groups

Parents in the video-alone condition were instructed not to interact with their child during viewing sessions. Those in the coviewing condition were instructed to watch with their child as they typically would at home and were told they could engage in any of the following behaviors: directing their child's attention to the screen, imitating signs, and eliciting sign production from the child during viewing. Although such mediated (i.e., interactive and responsive) coviewing was encouraged, it was not mandated.

Parent Instruction Group

Parents in the parent instruction condition were instructed to introduce their infants to the 18 signs

using the picture book. Parents were encouraged to teach their infants signs as they might teach new words from picture books at home and to point to the photographs and use verbal labels as well as signs. They were asked to limit instruction time to a maximum of 20 min per day, 4 days a week, to match exposure in the video viewing conditions.

Parents in all conditions were instructed to avoid using or imitating signs outside of the viewing or instructional sessions. If infants signed between instructional sessions, parents were asked to acknowledge the sign verbally and not to imitate it themselves. No instructions were specified regarding the use of verbal labels for the target objects outside of the viewing environment. Parents were asked to complete a diary at home documenting the date of each instructional session and noting if they saw their child producing a sign during a session or using a sign appropriately in between sessions. After completing 3 weeks of sign instruction, parents were directed not to expose their infants to any signs for 1 week prior to returning to the laboratory at the end of the 4th week.

Learning Assessments

Children and parents in all conditions visited the laboratory weekly for 4 weeks for a total of five visits including baseline intake, to complete sign learning assessments. Learning assessments included a weekly parent report checklist, a weekly forced-choice comprehension task, and a single elicited production task administered at the fifth visit after a week without at-home exposure.

Parent Report

Parents indicated weekly on a vocabulary checklist whether their infants comprehended or produced appropriately each of the 18 target signs. They also indicated whether their infants comprehended or produced the verbal labels corresponding to the signs (see Appendix S2 in the online Supporting Information).

Forced Choice

The laboratory-based forced-choice task was designed to measure sign comprehension. The experimenter, who sat across a table from the infant, placed photographs of two objects from the stimulus set (e.g., airplane and dog) on the table and produced the sign for one of them (e.g., the airplane sign), asking the child, "Can you get it?" To minimize fatigue, the experimenter administered six trials at each laboratory visit with the target items randomly selected. Across sessions, all items were tested at least once. Objects in each picture pair were matched for salience based on pilot testing with 15-month-olds (n = 19) who did not participate in the experiment proper. During piloting, we selected pairings we believed were well matched for salience and presented them to the infants, asking them to "get one." Any pairings that elicited a bias toward selecting one object were altered by pairing more salient objects from one pair with more salient objects from another pair and readministering the choice elicitation with additional infants to ensure that infants did not exhibit default systematic preferences within any pairing.

Experimenters were generally blind to condition assignment, although conversations with parents occasionally inadvertently revealed to which condition the infant was assigned. The experimenters were instructed to ensure that the two picture cards and sign production were equidistant from the child, and to ensure that their eye gaze while eliciting a choice remained fixed on the infant's face. Coders were also blind to condition.

Elicited Production

On their final visit, in addition to completing the checklist and forced-choice comprehension task, infants in the experimental conditions also completed an elicited sign production task as a conservative test of learning and retention. We also administered the elicited production task to five infants in the no-exposure control group but discontinued this with subsequent control participants due to the distress and confusion displayed by these infants. None of the five who participated produced any signs.

This measure was somewhat exploratory as infants of this age often fail to produce communicative signals in laboratory-based elicited production tasks. As a result, we expected that production would be low, but nonetheless had the potential to provide a compelling index of depth of learning. To elicit production, the experimenter presented photographs of the target objects one at a time and elicited the sign by asking the infant, "Can you say [points to photograph] this with your hands?" or "Can you show me [verbal label] with your hands?" The number of trials administered varied across infants based on their attention and fussiness (M = 7.61 trials, SD = 3.92, range = 2–18). Eleven infants from the experimental groups did not com-

plete this task due to fussiness (4 = video alone, 3 = supported video, 4 = parent instruction). This resulted in a total sample size for this measure of 57 across the three experimental conditions.

Coding

A coder blind to condition classified the infants' choices during the forced-choice task and the infants' responses to the sign elicitation from video. Choice response was based on which card the infant first touched. Elicitation was coded by crediting infants with correct sign production if they produced an intentional hand movement that included at least *two* of the *three* central elements of the sign: hand shape, motion trajectory, and sign-space location, which were each coded independently. A second coder evaluated a randomly selected 10% of the sessions. Intercoder agreement was 97% on forced-choice trials and 87% on elicited production.

Results

Next, we report the parent report data for both sign learning and word learning followed by the more conservative laboratory-based forced-choice sign comprehension and elicited sign production measures. Data collected during the first 3 weeks of the study (four laboratory visits including baseline) were used to evaluate learning whereas data collected after the no-exposure delay were analyzed separately as a measure of retention.

Parent Report

We investigated infants' baby sign learning as well as parents' report of children's use of *verbal* labels for each of the 18 target objects. We tracked verbal label acquisition both as a replication of previous longitudinal research and as a manipulation check to ensure that there were no systematic reporting biases exhibited by parents in particular conditions. For both sign and word production, we calculated the proportion of target items (of 18) that parents reported their children produced each week. We investigated whether parents reported growth in target sign and verbal label acquisition over time and whether this varied as a function of exposure condition using two-way analyses of variance (ANOVAs) with exposure condition (video alone, coviewing, parent instruction, and no-exposure control) as a between-subjects variable and laboratory visit (baseline, 1, 2, 3) as a within-subject variable.

Sign Learning

We analyzed the proportion of signs parents reported infants produced using a two-way (Condition × Laboratory Visit) ANOVA. This analysis yielded a main effect of condition, $F(3, 88) = 7.01$, $p < .0005$, partial $\eta^2 = .19$, and a main effect of laboratory visit, $\Lambda = .49$, $F(3, 86) = 29.34$, $p < .0005$, partial $\eta^2 = .51$, mediated by a Condition × Laboratory Visit interaction, $\Lambda = .66$, $F(9, 88) = 4.33$, $p < .0005$, partial $\eta^2 = .13$ (see Figure 1). This interaction was driven by the control group, which deviated from the three experimental conditions. Whereas parents of infants in all three experimental groups reported growth in their children's sign production across laboratory visits, those in the control condition did not. A follow-up analysis that excluded the control condition revealed only a main effect of laboratory visit, $\Lambda = .43$, $F(3, 63) = 28.14$, $p < .0005$, partial $\eta^2 = .57$, suggesting that the exposure conditions did not differ reliably from each other. Follow-up one-way ANOVAs comparing the four conditions for each laboratory visit independently revealed no condition effects at baseline or after 1 week of exposure, but a reliable condition effect after 2 weeks, $F(3, 88) = 6.04$, $p = .001$, and 3 weeks of exposure, $F(3, 88) = 11.05$, $p < .0005$, suggesting that parents in the experimental conditions began to observe evidence of learning after 2 weeks of exposure. Post hoc analysis using both Tamhane (to adjust for violation of homogeneity given that parents never reported any sign production in the control group) and Tukey's honestly significant difference (HSD) test indicated that all three experimental conditions differed from control after 2 weeks' exposure. None of the experimental conditions differed reliably from each other at any laboratory visit, although the difference between coviewing and video alone approached significance at Laboratory Visit 3 (Tukey's $p = .064$).

Word Learning

We predicted that acquisition of verbal labels for the included objects would increase over time at this age in all four conditions, due to incidental daily exposure. However, exposure to the baby signs also enhanced exposure to the accompanying verbal labels. To assess whether heightened exposure to the verbal labels in the sign exposure conditions accelerated word learning, we conducted an ANOVA on parent report of children's word production for these 18 items with condition as a between-subject variable and laboratory visit (baseline, 1, 2, 3) as a

within-subjects variable. As expected, there was a main effect of laboratory visit indicating vocabulary growth over time, $\Lambda = .47$, $F(3, 86) = 31.67$, $p < .0005$, partial $\eta^2 = .52$. However, there was no effect of condition and no interaction (see Figure 2).

Sign Retention

We conducted a one-way ANOVA to assess condition differences in sign retention as indicated by parental report at Laboratory Visit 4 (following the 1-week retention interval). This analysis yielded a significant condition effect, $F(3, 87) = 14.68$, $p < .0005$. Post hoc analysis using Tamhane revealed significant differences between the experimental groups and the control group ($m = .0116$), $p < .01$, but no differences among experimental groups. Tukey's HSD, a less conservative measure, indicated that parents of infants in the coviewing condition ($m = .442$) group reported that their infants produced significantly more of the signs than those in the video-alone condition ($m = .242$),

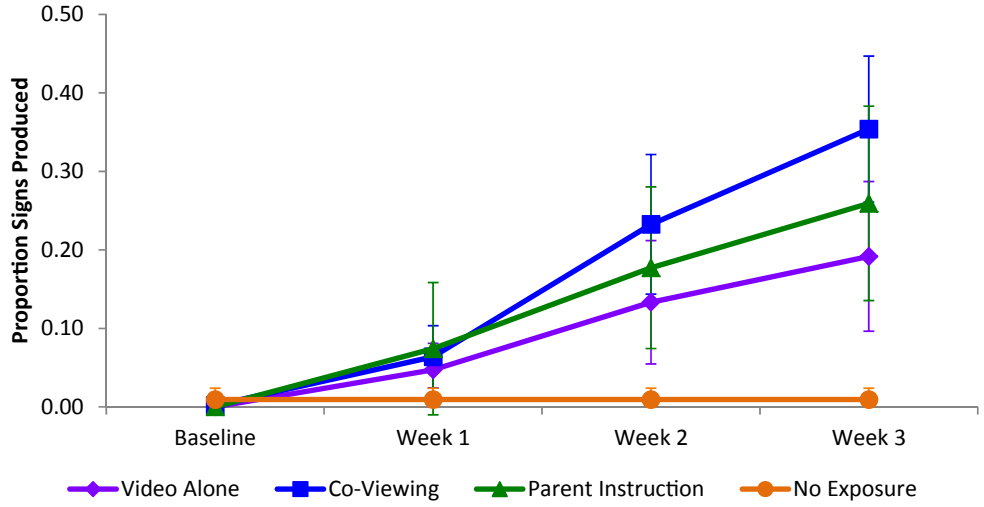

Figure 1. Mean proportion of signs accumulated across sessions in each condition, based on parental report. Error bars indicate confidence intervals (95%).

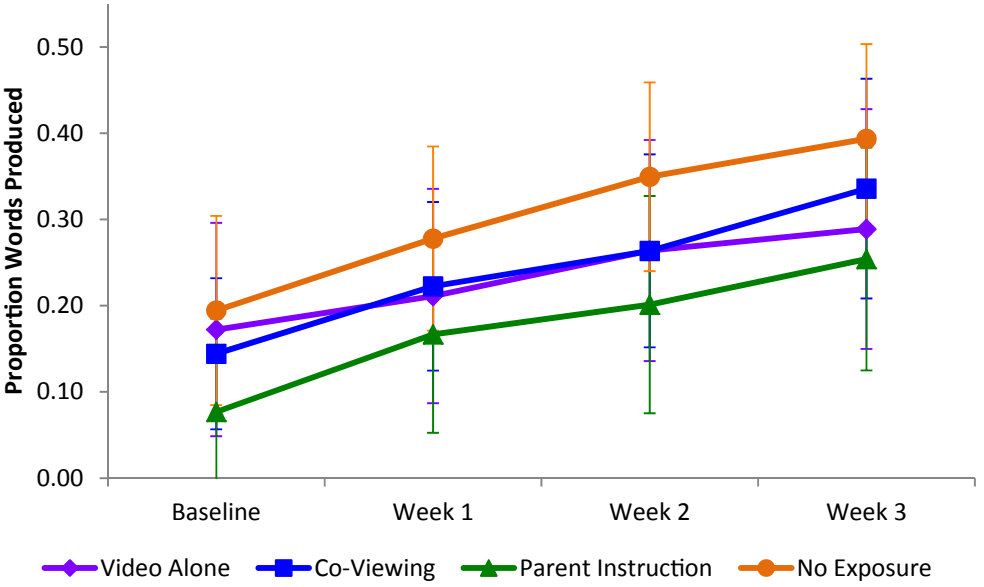

Figure 2. Mean proportion of words accumulated across sessions in each condition, based on parental report. Error bars indicate confidence interval (95%).

p = .025. Parents reported an intermediate level of sign production in the parent instruction condition (m = .310) that did not differ reliably from either of the other sign exposure conditions.

Forced-Choice Assessment

The proportion of forced-choice trials (of six) on which infants selected the target picture was calculated for each laboratory visit. Given the longitudinal nature of the study, there were occasional missing data points due either to a missed laboratory visit or infant fussiness. Overall, there were a total of 21 missing data points of 460 planned laboratory visits (< 5%). These missing laboratory visits were distributed across 19 participants (1 in the video alone, 12 in the coviewing, 4 in the parent instruction, and 4 in the control condition). Missing data points were replaced by the mean of the remaining children in the same condition for the same laboratory visit (see Parent, 2013; Rubin, Witkiewitz, St. Andre, & Riley, 2007, for support for this approach).

Sign Learning

We conducted two sets of analyses on the laboratory-based forced-choice sign learning task. We compared performance in the experimental groups both to performance in the control condition and to chance (random, 50%) responding. We compared the performance of each condition (including the control condition) to chance using single-sample t tests. Comparisons to the control condition (and among experimental conditions) involved two-way Condition × Laboratory Visit ANOVAs.

Comparisons to chance indicated, as expected, that control performance did not differ from chance at any laboratory visit. Children in the video-alone condition responded at chance at the baseline visit and after 1 and 2 weeks of exposure but performed at above chance rates after 3 weeks of viewing, $t(19) = 4.15$, $p = .001$. In the coviewing condition, the same pattern was observed with performance above chance only at Laboratory Visit 3, $t(26) = 2.51$, $p = .018$. The parent instruction group exhibited chance performance at baseline and Laboratory Visits 1 through 3, performing marginally above chance in Laboratory Visit 3, $t(20) = 2.05$, $p = .053$.

An ANOVA with condition as a between-subject factor and laboratory visit (baseline, 1, 2, 3) as a within-subject factor yielded a main effect of laboratory visit, $\Lambda = .90$, $F(3, 86) = 3.01$, $p = .035$, partial $\eta^2 = .09$, indicating overall improvement with exposure. There was also a marginal effect of condition, $F(3, 88) = 2.17$, $p = .097$, partial $\eta^2 = .07$ (see Figure 3). The interaction was not significant, $\Lambda = .89$, $F(9, 88) = 1.13$, $p = .342$, partial $\eta^2 = .04$. Post hoc analysis using Tukey's HSD indicated that the marginal main effect of condition was driven by a reliable overall difference between the video-alone scores ($M = .55$, $SD = .16$) and the control condition scores ($M = .49$, $SD = .18$), $p = .049$. No other pairwise condition differences were significant.

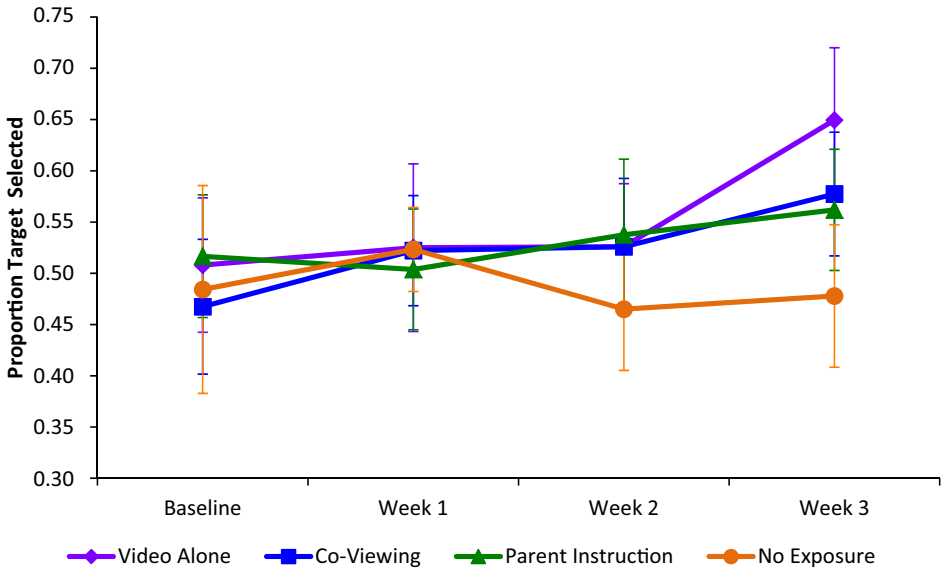

Figure 3. Mean proportion of target selected across sessions in each condition, based on forced-choice task. Error bars indicate confidence interval (95%). Chance = .50.

Comparing Parent Report and Forced-Choice Measures

Parent report of infants' signing and performance in the forced-choice task at Laboratory Visit 3 were marginally significantly correlated collapsed across all conditions, $r(84) = .178$, $p = .10$. However, this correlation was nonsignificant when infants in the control condition were removed from the analysis, $r(61) = .049$, $p = .70$.

Sign Retention

We conducted a separate analysis of performance on the forced-choice task at Laboratory Visit 4 after a 1-week delay during which children were not exposed to the baby signs. Comparisons to chance indicated that only those in the parent instruction group performed significantly above chance after a 1-week retention interval, $t(19) = 2.85$, $p = .010$. A one-way ANOVA revealed no reliable differences across conditions at this laboratory visit (see Figure 4a).

At the sign retention session, there was a significant correlation between parent report and performance on the forced-choice task collapsed across all conditions, $r(84) = .247$, $p = .022$. The correlation remained marginally significant when infants in the control condition were removed from the analysis, $r(62) = .202$, $p = .11$.

Elicited Production as a Measure of Sign Retention

Performance on the elicited production task administered at the final Laboratory Visit (after a 1-week delay with no exposure) was measured based on the proportion of signs elicited that infants produced. Children's mean production across conditions is reported in Figure 4b. Because only five infants completed the task in the no-exposure control condition and none of those infants produced any signs, we did not analyze the data from this condition further. Single-sample t tests comparing each experimental condition to the expected population mean of zero (representing no knowledge of the target signs) indicated that infants in all three experimental groups showed significant evidence of learning (ts = 5.47, 5.94, and 6.93 for the video-alone, coviewing, and parent instruction conditions, respectively, all ps < .0005). A one-way ANOVA with condition (video alone, coviewing, and parent instruction) as a between-subjects variable revealed no significant differences in rates of elicited sign production across the sign exposure conditions, $F(2, 52) = .18$, $p = .832$.

Among those infants who participated in the elicited production task, 82% of video-alone infants ($n = 16$) and 100% of those in the coviewing ($n = 23$) and parental instruction groups ($n = 17$) produced at least one sign successfully. However, performance in the elicited production task was not correlated with either parent report, $r(53) = -.039$, $p = .778$, or forced-choice performance, $r(52) = .004$, $p = .978$, at Laboratory Visit 4 (collapsed across experimental conditions), suggesting that the production task may better serve as an existence proof for learning than an accurate index of how many signs were retained.

Discussion

These data indicate that infants under the age of 2 can learn baby signs from video, even without the support of parents during viewing. Parent report and laboratory-based assessments revealed striking evidence of learning after 3 weeks of exposure (12 viewings) in all three experimental conditions. The evidence for sign retention was mixed. The forced-choice measure suggested that only those in the parent instruction condition retained the signs after a week without exposure. However, infants in all three experimental conditions reliably *produced* signs in the laboratory after a 1-week delay. Because production is typically considered the more conservative measure, and evidence of production clearly implies comprehension, it appears that infants in all three exposure conditions retained at least some sign knowledge over a delay. However, given that the production measure relies on performative factors such as fatigue and shyness, it is not likely to be the most sensitive index of variability in retention across conditions. The absence of correlations between elicited production and either the parent report or forced-choice assessment underscores that the production measure was a less sensitive index.

Interestingly, the more sensitive forced-choice data suggest that children in the parental instruction condition exhibited a "sleeper" effect, exhibiting marginally above-chance performance in the forced-choice task after 3 weeks' exposure but robust evidence of learning after an additional week without exposure. The superior performance of the parent instruction condition relative to the video-viewing conditions after a delay may reflect a video deficit in retention after as little as 1 week. Taken together, the findings from this study suggest the potential for video-based learning but hint

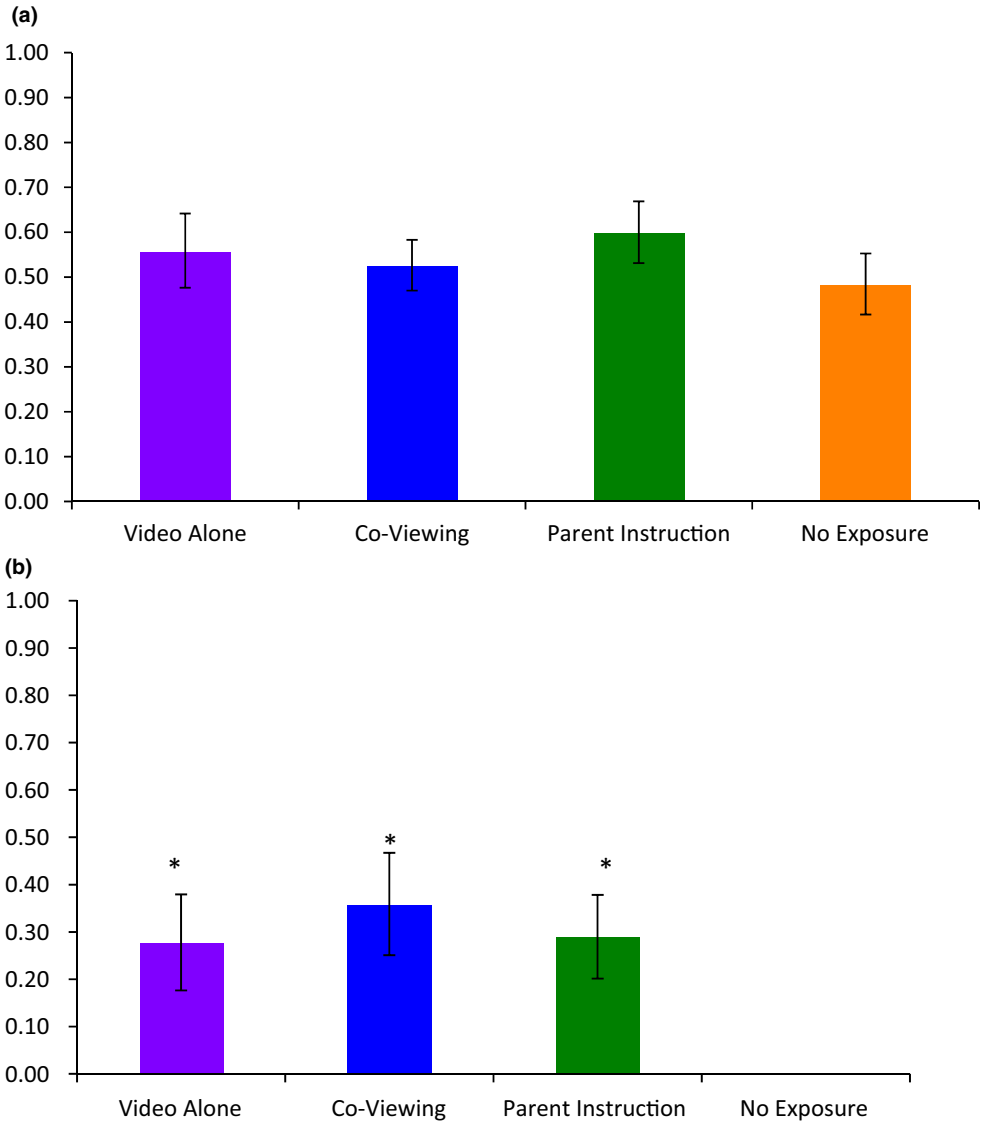

Figure 4. (a) Mean proportion of target selected after a 1-week delay, based on forced-choice task. Error bars indicate confidence interval (95%). Chance = .50. (b) Mean proportion of elicited signs produced after a 1-week delay. Error bars indicate standard error. *Indicates reliable difference from zero, indicating learning ($p < .001$).

that the most robust retention occurs following traditional parent instruction.

The parental report data echoed the laboratory-based evidence suggesting learning across all exposure conditions. According to parent report, all three sign exposure groups exhibited learning after 3 weeks' exposure. The two parent-supported groups (i.e., coviewing and parental instruction) reported numerically, but not statistically, higher rates of learning than those who viewed videos alone, according to parental report. This evidence of more robust learning in parentally supported learning environments was predicted and may imply that the medium through which information is presented is less critical to infant learning than the involvement of a parent in the learning endeavor. However, the fact that these differences emerged only in the parental report measure raises the possibility that this outcome may be due, at least in part, to either greater sensitivity to sign production or over-reporting among parents who had participated in the learning sessions.

Although we anticipated that the infants in the parent instruction condition would demonstrate evidence of learning, it is worth noting that parents in this condition reported that they found the instructional sessions challenging. The task may not have been especially naturalistic, given that parents

needed to simultaneously manipulate the book, sustain their infants' attention, and track which signs to use. That the parents were teaching material with which they were not especially familiar may also have limited their consistency or comfort with producing the signs during interactions with their infants. In contrast, the adults on the commercial videos were adept signers. This, in conjunction with the more dynamic information included in the videos, may actually have limited learning potential in the parent instruction condition (Simcock, Garrity, & Barr, 2011).

It is notable that infants whose parents supported learning were successful at acquiring signs from both picture books and videos. However, our most surprising finding is that those in the video-alone condition learned the signs as well. There are several factors that may have contributed to learning in this condition. The first is that infants were exposed to the videos repeatedly over the course of the study and repetition seems to support learning from video (Barr, Muentener, & Garcia, 2007; Barr, Muentener, Garcia, Fujimoto, & Chávez, 2007; Strouse & Troseth, 2008). In addition, although signs serve the same communicative functions as words, they are based on manual movement; Numerous imitation studies demonstrate infants' ability to learn a sequence of movement from a screen (Barr & Hayne, 1999; Barr, Muentener, & Garcia, 2007; Barr, Muentener, Garcia, Fujimoto, et al., 2007; Barr, Shuck, Salerno, Atkinson, & Linebarger, 2010; Barr & Wyss, 2008; Hayne, Herbert, & Simcock, 2003; Meltzoff, 1988a, 1988b; Strouse & Troseth, 2008). Furthermore, verbal labels, included in the elicited production task, may have served as reminders for the movements (Barr & Wyss, 2008; Hayne & Herbert, 2004; Khu, Graham, & Ganea, 2013). Although signs did serve as labels in this context, it may be that this manual form of labeling is easier to learn from the screen than is verbal labeling. Furthermore, the familiarity with the words and objects may have scaffolded learning by drawing infants' attention to the movement associated with the familiar word and referent (Strouse & Troseth, 2014). The fact that viewing alone did not require infants to divide their visual attention between the screen and the parent might also have aided learning in this context (Strouse & Troseth, 2014).

Although not a direct goal of our study, we also tracked *word* learning across laboratory visits via parent report. As we anticipated, word learning increased over time for the stimulus items involved in this study, but the rate was consistent across all conditions, including the no-exposure control condition. This outcome replicates previous longitudinal studies suggesting no enhanced word learning following 4 weeks of exposure to a commercial video as measured by parent report (see Robb et al., 2009) and forced-choice assessments (see DeLoache et al., 2010). That the parent instruction condition did not show accelerated learning relative to the video viewing conditions differs from DeLoache et al.'s (2010) findings. This may have been due to the lack of emphasis on verbal labels in this study, or to the more limited duration and frequency of exposure that we employed relative to DeLoache et al. Because these words are frequent in input to children, it may be that the degree of enhanced exposure employed in our study was either insufficient or unnecessary to impact the rate of word learning. However, the dissociation between word learning and gesture learning raises important questions for future research regarding how video learning varies for different learning materials. Of particular interest is whether the visual versus auditory modality impacts the relative efficacy of video versus live instruction (see Brito, Barr, McIntyre, & Simcock, 2012; Simcock et al., 2011, for additional discussion of this issue).

Conclusion

This experimentally controlled, longitudinal investigation reveals that, at least for some stimuli and some video formats, infants exhibit a surprising ability to acquire information obtained via video viewing. These findings bolster Vandewater's (2011) findings that infants' communicative repertoire can be expanded through video exposure, and add to the literature by generalizing to sign learning and to production measures. Although the effects were nominally more robust in the parent-supported learning conditions, even infants who viewed videos alone exhibited clear evidence of learning over the course of 3 weeks' exposure. Because infants viewed multiple presentation formats, we cannot determine how format or formal features (e.g., use of foreground music vs. background music vs. no music) impact learning. Likewise, we cannot determine the optimal duration or frequency of exposure to facilitate learning. This study also does not address the potential risks associated with exposure to media. Nevertheless, we find clear and compelling evidence that, at least for baby signs, videos constitute one possible instructional medium for infants.

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Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's website:

Appendix S1. Example Pages From Picture Book for the Target Signs "Car," "Cat," and "Fish"

Appendix S2. Vocabulary Checklist