The effect of repetition on imitation from television during infancy

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The Effect of Repetition on Imitation from Television during Infancy

ABSTRACT: *Although television exposure levels during infancy are high, the impact of such exposure on learning is relatively unknown. Initial studies have shown that infants imitate significantly fewer target actions from a televised demonstration than they imitate from a live demonstration. It was hypothesized that increasing the duration of exposure to the videotaped demonstration would increase learning from television. Independent groups of 12- to 21-month-olds were exposed to live or videotaped demonstrations of target actions, and imitation of the target actions was measured 24 hr later. The video segment duration was twice that of the live presentation. Doubling exposure increased levels of imitation performance in the video groups to that of the live groups, and both groups exceeded baseline performance. These results are consistent with the perceptual encoding impoverishment theory, and we conclude that repeated exposure enhances encoding of the target actions from a 2D television source. © 2007 Wiley-Periodicals, Inc.* Dev Psychobiol 49: 196–207, 2007.

Keywords: *imitation; memory; infant; television; transfer of learning*

INTRODUCTION

Historically, researchers chose imitation to investigate the potential impact of television exposure because it provided a direct measure of knowledge transfer in an ecologically valid manner (Bandura, 1965; Bandura, Ross, & Ross, 1963; Huston-Stein & Wright, 1979; Lemish, 1987; Lorch, Anderson, & Levin, 1979; Sprafkin, Gadow, & Abelman, 1992). In the classic studies conducted by Bandura, for example, 3- to 5-year-old children watched an adult behave aggressively toward an inflatable Bobo doll. Children who were exposed to the televised adult model exhibited high levels of aggressive behavior toward the doll when they were allowed to play with it immediately after the demonstration. Furthermore, children were just as likely to imitate aggressive acts modeled on television as they were to imitate them when modeled live (Bandura et al., 1963). Similar concerns about the potential negative impact of television apply to toddlers. More recently, the ability of preverbal and early-verbal infants to learn from televised presentations has also been examined using imitation studies (Barr & Hayne, 1999; Hayne, Herbert, & Simcock, 2003; Huang & Charman, 2005; Hudson & Sheffield, 1999; McCall, Parke, & Kavanaugh, 1977; Meltzoff, 1988). Initial studies have shown that 14- to 15-month-olds can imitate limited actions demonstrated by videotaped models (Barr & Hayne, 1999; Meltzoff, 1988).

However, studies also show that an infant's ability to learn multi-step sequences of actions from a televised demonstration is significantly less than an infant's ability to learn from a live demonstration. That is, infants exhibit a *video deficit effect* (Anderson & Pempek, 2005). For example, Barr and Hayne (1999) found that 15- and 18-month-olds in the live condition imitated significantly more target actions than infants of the same age in the video condition when tested after a 24 hr delay. Similarly, Hayne and colleagues (2003) found that both the 24- and 30-month-old infants in the video condition imitated significantly fewer actions than infants in the live condition when tested either immediately or after 24 hr. This discrepancy between imitation of live and video models continues until 3 years of age (Hayne et al., 2003; Hudson & Sheffield, 1999; McCall et al., 1977). The

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video deficit effect is not task specific. It is also observed using object search tasks (Deocampo & Hudson, 2005; Schmitt & Anderson, 2002; Troseth, 2003; Troseth & DeLoache, 1998), emotion processing tasks with infants (Mumme & Fernald, 2003) and language tasks with infants (Kuhl, Tsao, & Liu, 2003) and preschoolers (Sell, Ray, & Lovelace, 1995).

There are a number of potential explanations for the *video deficit effect.* One prominent explanation is the perceptual encoding impoverishment theory, which suggests that because the 2D input is impoverished relative to the 3D input, encoding is impoverished. By this account the *video deficit effect* is a direct result of poor perceptual encoding (Barr & Hayne, 1999; Schmitt & Anderson, 2002; Suddendorf, 2003). This theory is consistent with Johnson's more general theory of perception, termed the threshold model (Johnson & Aslin, 1996; Johnson, 1997), in which he argues that the perceptual system requires a minimum amount of information for perception regardless of its source (motion, stereopsis, 2D, or 3D stimuli). Across development, infants need information from fewer streams to perceive objects (Johnson, 1997, 2000). The ability to construct a complete 3D representation of an event may likewise depend on a summation or threshold process; a 2D presentation may not match its 3D counterpart until a sufficient number of individual sources of information are available to match from one to the other (see also Smith, 2000 for a similar argument regarding language acquisition). Consistent with this theory, researchers using event-related potentials (ERPs) have demonstrated that 18-month-olds process 2D images more slowly than they process 3D objects. They recognize a familiar 3D object very early in the attention process, and recognize a 2D digital photo of a familiar object significantly later (Carver, Meltzoff, & Dawson, 2006).

During imitation tasks, participants must form a representation of the target actions and reproduce them in the appropriate context. Successful completion of the imitation task from a videotaped model is even more complex and requires formation of both an object and an action representation that can be retained over a delay. At the time of the test, participants must transfer perceptual attributes of the 3D test object to stored attributes of the memory representation of the original 2D video display. Either the slower processing of 2D information or the cognitive load associated with transfer from 2D to 3D could account for the *video deficit effect*.

Given this theoretical account, it is somewhat surprising that researchers have rarely manipulated repetition to examine learning from television effects during infancy. Furthermore, from a practical point of view, infants often see material repeatedly due to the content of television programming and video technology. Parents report that preschoolers and toddlers frequently ask to repeatedly view the same program (Mares, 1998; Rideout, Vandewater, & Wartella, 2003). Moreover, repeated presentation of the same television program maintains attention and increases comprehension of television content by preschoolers (Abelman, 1990; Anderson & Levin, 1976; Anderson, Lorch, Field, & Sanders, 1981; Crawley, Anderson, Wilder, Williams, & Santomero, 1999; Sell et al., 1995; Skouteris & Kelly, 2006). Sell and colleagues, for example, showed preschoolers an episode of *Sesame St*. once a week for 3 weeks and found the plot comprehension increased significantly with repeated viewing of the episode. Similarly, Crawley and colleagues showed 3-, 4-, and 5-year-olds an episode of *Blues Clues*, once per day for 5 days. They found that looking time remained consistently high across the five episodes. Although there were significant age-related differences in comprehension scores, comprehension at all ages increased with repeated exposure to the program. Most recently, Skouteris and Kelly (2006) found that the effects of repetition on comprehension generalized to animated full-length movie presentations.

Although the effect of repetition on learning from television has not yet been systematically manipulated, repetition has consistently protracted infant retention following live demonstrations (e.g., Barr, Dowden, & Hayne, 1996; Barr, Rovee-Collier, & Campanella, 2005; Galluccio & Rovee-Collier, 2000; Ohr, Fagen, Rovee-Collier, Hayne, & Vander Linde, 1989). Barr and colleagues, for example, found that 12-, 18-, and 24-month-old infants presented with three demonstrations of the target actions could imitate those actions after a 24 hr delay, but 6-month-olds could not. However, if the number of demonstrations of the target actions was doubled to six, even 6-month-olds showed imitation after a 24 hr delay. Given that repetition facilitates preschoolers' comprehension of televised material, and repetition facilitates infant imitation following live demonstrations, we hypothesized that repetition would also facilitate infant imitation following a televised demonstration. The aims of the present study were threefold. First, the study examined the impact of repetition on looking time during the demonstration. Second, the study examined whether increasing the number of videotaped demonstrations of the target actions facilitated imitation of the target actions. Finally, the study examined whether infants younger than 14 months can imitate from television.

EXP. 1A. EFFECT OF REPEATED EXPOSURE ON LOOKING TIME AND IMITATION BY 15- TO 21-MONTH-OLDS

In Experiment 1a we replicated and extended Barr and Hayne (1999) in the following ways. First, in addition to measuring imitation of the target actions we also measured looking time during the demonstration session. Infant looking time during televised presentations had previously been reported to be extremely low (e.g., Anderson & Levin, 1976). We wanted to ensure that learning was not impaired because infants were looking more during live demonstrations than during video demonstrations. Previously, Barr and Hayne (1999, Exp. 2a) had only measured looking time by 15-month-olds during the demonstration phase of one of the imitation tasks. In the present study, we extended looking time measurements to all conditions. Second, and the most critical manipulation change from Barr and Hayne (1999), was that the number of demonstrations of the target actions was doubled from three to six demonstrations for the video group. We replicated the live group for comparison. Finally, we also included a group of 21-month-olds. We tested independent groups of 15-, 18-, and 21-month-old infants exposed to live or videotaped demonstrations of two novel, multi-step sequences of actions. The infants' ability to reproduce the target actions was assessed for the first time following a 24-hr delay. Exp. 1a attempted to determine the maximally effective number of presentations to yield imitation from television. Maximally effective was defined as the number of demonstrations that yielded no difference in imitation performance between live and video groups. It is important to note that exposure can be increased both within and across sessions (Barr et al., 1996; Ohr et al., 1989). Given that, Barr et al. found that 6-month-olds exhibited deferred imitation when the actions were doubled within one session, we decided to initially adopt this within session approach. This strategy yielded three *live 3x* groups and three *video 6x* groups. For each group, the number of demonstrations of the target actions was delineated as *3x* or *6x* to refer to the fact that they were shown the target actions three or six times respectively. To assess whether infants were performing above the rate of spontaneous production of the target behaviors we also tested independent age-matched controls in a *baseline control* group.

Participants

Participants were 108 full-term, healthy infants (58 girls, 50 boys) recruited from commercial mailing lists and by word of mouth. Infants were randomly assigned to the *live 3x, video 6x*, or *baseline control* groups ($n = 12$/group). The 15-month-olds had a mean age of 467.7 days ($SD = 10.4$), 18-month-olds had a mean age of 568.4 days ($SD = 8.7$), and 21-month-olds had a mean age of 651.6 days ($SD = 9.2$). Infants were African-American ($n = 8$), Latino ($n = 11$), Asian ($n = 6$), Caucasian ($n = 76$), and of mixed ethnic origin ($n = 7$). Their parents' mean educational attainment was 16.3 years ($SD = 1.0$), and their mean rank of socioeconomic status (Nakao & Treas, 1992) was 76.1 ($SD = 16.7$). A total of 22 infants were excluded from the sample for refusal to touch the stimuli at test ($n = 10$), excessive crying ($n = 2$), parental interference ($n = 6$), equipment failure ($n = 2$), or experimenter error ($n = 2$).

Apparatus

The stimuli used in the present experiment were identical to those used by Herbert and Hayne (2000ab). There were four sets of stimuli, two rattles and two animals. The two versions of each stimulus set (rattle and animal) were constructed in such a way that the exact same target actions could be performed with each version (see Table 1).

The stimuli for the *green rattle* consisted of a green stick (12.5 cm long) attached to a yellow plastic lid (9.5 cm in diameter) with velcro attached to the underside of the lid, a blue octagonal bead (3 cm in diameter × 2.5 cm in height), and a clear plastic square cup with velcro around the top (5.5 cm in diameter × 8 cm in height). The opening of the plastic cup (3.5 cm in diameter) was covered with a 1 mm black rubber diaphragm, with 16 cuts radiating from the center. The stimuli for the *red rattle* consisted of a red wooden stick (12.5 cm long) with a plug on the end which fitted into a clear plastic ball with a hole cut in the top (4 cm in diameter), and a clear plastic bead (2 cm in diameter) with a blue ring (2.5 cm diameter).

Table 1. The Three Target Actions for the Four Sets of Stimuli Used in Experiments 1a–c

Stimulus Set	Step 1	Step 2	Step 3
Green rattle	Push block through diaphragm into jar	Put stick on jar attaching with Velcro	Shake stick to make noise
Red rattle	Put the bead in the jar	Push the stick into the top of the jar	Shake stick to make noise
Rabbit	Pull lever in a circular motion to raise ears	Place eyes on face attaching with Velcro	Put the carrot in the rabbit's "mouth"
Monkey	Pull lever in a circular motion to raise ears	Place eyes on face attaching with Velcro	Put the banana in the monkey's "mouth"

The stimuli for the *rabbit* toy consisted of two plastic eyes (3 × 2 cm) attached to a 9 × 6 cm piece of plywood with velcro on the back, a 12 cm orange wooden carrot with green string attached to the top, and a white circle of wood (the head, 15 cm in diameter) mounted horizontally on a white rectangular wooden base (30 × 20 cm). A 3 cm (in diameter) hole was drilled at the bottom of the head and a 5 × 15 cm piece of white velcro was attached to the top of the head. Two white ‘‘ears’’ (20 × 5 cm) decorated with stripes of pink felt were hidden behind the head. A 10 cm wooden stick attached to the top of the right ear allowed the ears to be pulled up from behind the head in a circular motion to a point above the head. The stimuli for the *monkey* toy consisted of two plastic eyes (2.5 cm in diameter) with eyelashes that were attached to a piece of brown plywood in the shape of two diamonds joined at the center (11.5 cm in width, 6.5 cm in height), with brown velcro on the back, a 20.5 cm yellow plastic banana, and a brown wooden head and shoulders shape mounted horizontally on a brown rectangular wooden base (22 × 38 cm). A 4-cm hole was drilled at the bottom of the head and a 5 × 18 cm piece of brown velcro was attached to the top of the head. Two brown ears (3.5 × 7 cm) decorated with a piece of yellow felt were hidden behind the head. A 3-cm lever with a wooden button (3.5 cm in diameter) on the top, attached to the right ear, allowed for the ears to be pulled up from behind the head in a circular motion to the side of the head.

Procedure

During the initial visit, the purpose of the study and details of the procedure were explained to the caregiver, and informed consent was obtained. All infants were tested in their homes at a time of day that the caregiver identified as an alert/play period. At the beginning of each session, the experimenter interacted with the infant for approximately 5 min or until a smile was elicited.

Demonstration Session

The live and video demonstration conditions were equated as much as possible. For both groups, an experimenter demonstrated three specific actions with two different sets of stimuli, one rattle and one animal (see Table 1). The order of presentation of the stimulus sets was counterbalanced across participants. The experimenter demonstrated the target actions for the first set of stimuli, and then she demonstrated the target actions for the second set of stimuli. The target actions were always demonstrated in the order shown in Table 1. Narration did not accompany either presentation. Caregivers were asked to refrain from describing the actions. If the infant looked away during the demonstration, caregivers were told to use the infants' name or the word ‘‘look’’ to redirect attention back to the demonstration (Barr & Hayne, 1999; Hayne et al., 2003; Lemish, 1987). The experimenter also did not describe the target actions. Rather, to maintain the infants' attention on the test stimuli, the experimenter used phrases like, ‘‘Isn't this fun?’’ or ‘‘One more time,’’ speaking in a manner characteristic of ‘‘motherese,’’ that is commonly used by adults in television programs aimed at child audiences (Anderson et al., 1981; Rice & Haight, 1986). In order to later accurately measure looking time during the demonstration, the infant's face was videotaped.

For infants in the *live 3x* group, the experimenter sat opposite the infant and the caregiver on the floor, such that the stimuli were out of the infant's reach. The total demonstration time for each set of stimuli was on average 30 to 40 s ($M = 36.0$ s, $SD = 6.5$). The variation in the live demonstration times were due to differences in the time taken by the experimenter to disassemble the stimuli, and occasional interruptions in the household such as a phone ringing. For these reasons, we coded looking time during the entire demonstration, including any pauses between the demonstration of the target actions, and also during the demonstration of the target actions alone.

For infants in the *video 6x* group, the television viewing conditions were identical to those used in prior studies of imitation from television (Barr & Hayne, 1999; Hayne et al., 2003). All infants were seated on the caregiver's lap during the demonstration approximately 80 cm from the family's most used television set such that the screen was at the infant's eye level but was out of reach. The participants' home television screens ranged from 33 to 127 cm with an average screen size of 64.83 cm ($SD = 15.4$) and all were color. During the video demonstration, the experimenter remained in the room. Infants in the *video 6x* group watched as a different experimenter performed the same three specific actions with the sets of stimuli, however, each set of actions was demonstrated six times on prerecorded videotape and the total demonstration for each set of stimuli was 60 to 63 s.

At the beginning of each videotape, infants saw the head and torso of the male experimenter but the stimuli were not visible. The experimenter began the video demonstration by saying ‘‘Look at this.’’ Next, infants saw a close-up of the experimenter's hands as he modeled the target actions for one repetition (Barr & Hayne, 1999; McCall et al., 1977). Next, they saw the head and torso of the male experimenter again. The demonstration alternated between close-ups of the target actions and the head and torso of the male experimenter. The experimenter on the video demonstrated the actions with one set of stimuli six times and then demonstrated different actions with the other set of stimuli six times. The actions were demonstrated in exactly the same manner as for infants in the *live 3x* group. Between the presentation of one set of stimuli and the other, there was a 1 s fade out to black.

Test Session

The test session was scheduled 24 hr (±5) after the demonstration session and was identical for infants in the *live 3x* and *video 6x* conditions. During the session, the infant and the experimenter were seated facing each other on the floor; the caregiver was seated behind the infant and held him/her gently by the hips. Each infant was tested with the same sets of stimuli represented in the same order that he or she had seen during the demonstration the day before. The experimenter who visited on the first day always visited on the second day. Caregivers were instructed to refrain from describing the target actions. During the test, the experimenter positioned the stimuli within the infant's reach, and the infant's behavior was coded for 60 s from the time he or she first touched one of the objects in the stimulus set. The infant was then given the second set of stimuli, and his or her behavior was recorded for an additional 60 s from the time he or she touched one of the objects in the second set of test stimuli. The *baseline control* group was used to assess the spontaneous production of the target actions in the absence of the demonstration. Infants in the *baseline control* group did not participate in the demonstration session and were shown the test stimuli for the first time during the test session. They were tested in a manner identical to that of the experimental groups. All infants were videotaped during the test session. The video camera was placed to the side of the infant to ensure that all target actions could later be accurately coded.

Coding and Reliability

During the demonstration session, percent looking time was coded from videotaped sessions (Anderson & Levin, 1976). Based on 39% of the demonstration sessions, a Pearson product-moment correlation yielded an inter-observer reliability coefficient of .91 (Rovee-Collier & Barr, 2001). During the test session, both observers noted the total number of target actions that each infant imitated for each rattle and animal stimulus set during the videotaped test session (range 0–3 per task). Based on 59% of the test sessions, interobserver reliability for imitation scores was 95.4% (Kappa = .91).

RESULTS AND DISCUSSION

Preliminary Analyses

Preliminary analyses revealed that there were no main effects of experimenter, gender, or order of stimulus presentation on outcome, so data were collapsed across these variables for all subsequent analyses.

Demonstration Session

Percent looking time to the *live 3x* demonstration and the *video 6x* demonstration was high (95.4%, $SE = .6$ and 93.7%, $SE = .9$, respectively). A 3 (Age) × 2 (Group: *live 3x*, *video 6x*) between subjects ANOVA across % looking time to the demonstration yielded no main effect of Age, $F(2, 66) < 1$, or Group, $F(1, 66) = 2.39$, *ns*, and no Age × Group interaction, $F(2,66) < 1$. The fact that there were no group differences in the percentage of time that infants looked at the demonstration means that subsequent differences in imitation could not be attributed differences in looking time. More importantly, the increased length of the videotaped demonstration did not decrease the overall percent looking time.

Test Session

An overall imitation score per participant was calculated by adding together the total number of target actions for the two sets of stimuli (total possible score = 6). A 3 (Age) × 3 (Group: *live 3x*, *video 6x*, *baseline*) between-subjects ANOVA was conducted on overall imitation score. The data averaged across the two sets of stimuli are shown in the right panel of Figure 1. There was a main effect of Age $F(2, 99) = 12.52, p < .0001$, a main effect of Group, $F(2, 99) = 52.64$, $p < .0001$, and no significant interaction, $F(4, 99) = 1.06$, *n.s.*, and a very large effect size, $d = 1.08$ (Kirk, 1995). Post-hoc Student Newman Kuhls tests (SNK, $p < .05$) examining the main effect of Group showed that there was no significant difference between the *live 3x* and *video 6x* groups and that both groups had significantly higher imitation scores than the age-matched *baseline control* groups. To examine the main effect of Age, post-hoc SNK tests ($p < .05$) were conducted and revealed that the mean imitation score of the 15-month-olds was significantly lower than the 18-month-olds, which was significantly lower than the mean imitation score of the 21-month-olds. That is, there were significant age-related increases in imitation performance across the 15- to 21-month-old age range (see also Barr & Hayne, 1999; Herbert & Hayne, 2000b).

Exp. 1a replicated and extended Barr and Hayne's (1999) original findings. The *live 3x* and *baseline* groups replicated the original findings and the *video 6x* groups also performed above baseline as before. The new findings were, however, that doubling the number of demonstrations maintained looking time to the video demonstration, and also ameliorated the video deficit effect. That is, giving additional exposure to the target actions was

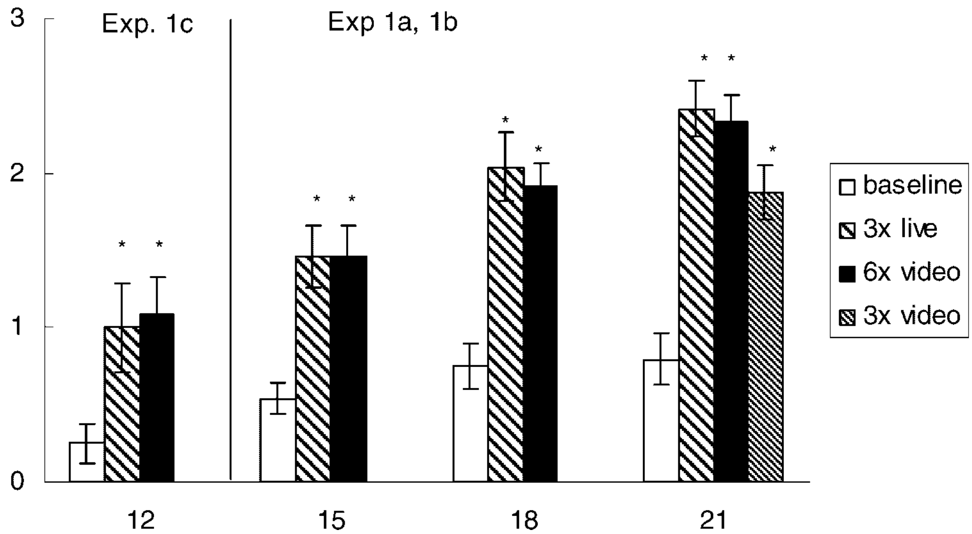

FIGURE 1 The mean imitation score (±1 SE) of infants as a function of age and experimental condition. **Left panel**. The 12-month-olds participated in Exp. 1c. **Right panel**. The data for the 15- to 21-month-olds were averaged across the two 3-step tasks to make their data comparable with the 12-month-old data. The 15- to 21-month-olds *live 3x* and *video 6x* groups participated in Exp. 1a. The 21-month-olds in the *video 3x* group participated in Exp. 1b.

enough to equate the imitation performance of the live and video groups.

EXP. 1B: THE VIDEO DEFICIT EFFECT IN 21-MONTH-OLDS

Exp. 1a demonstrated that the video deficit effect was ameliorated by repetition of the target actions during the televised demonstration. Apart from the repetition of the target actions, were there other reasons to expect differences in the respective samples? It is possible that the live and video groups performed equivalently in Exp 1a because (1) infants are now being exposed to greater amounts of television or because (2) different stimuli were used in the Exp. 1a than were used in the Barr and Hayne (1999) study. To rule out these possibilities, we used a partial replication design of the Barr and Hayne (1999) procedure to examine whether the video deficit effect would be replicated with 21-month-olds. We chose 21-month-olds for three reasons. First, this specific age group had not been tested before. They are slightly older than the Barr and Hayne (1999) study groups and slightly younger than the Hayne et al. (2003) age group. Second, diary records that we have collected indicate that 21-month-olds are exposed to more infant-directed programming than younger infants. Third, they performed best on the test stimuli in the *live 3x* group in Exp. 1a. Taken together, these three factors made it most likely that they would not exhibit a *video deficit effect*. To test this hypothesis, a *video 3x* group was shown a video with three repetitions of the target actions.

Participants

Participants were 12 full-term, healthy 21-month-olds (6 girls, 6 boys) recruited as before with a mean age of 651.3 days ($SD = 10.3$). Infants were African-American ($n = 1$), Latino ($n = 2$), Asian ($n = 2$), mixed origin ($n = 2$), and Caucasian ($n = 5$). Their parents' mean educational attainment was 16.3 years ($SD = .8$), and their mean rank of socioeconomic status (Nakao & Treas, 1992) was 75.5 ($SD = 17.5$). Attrition was low: infants were excluded from the sample for refusal to touch the stimuli at test ($n = 1$), parental interference ($n = 1$), and equipment or experimenter error ($n = 1$). The 21-month-old *live 3x* and *baseline control* groups from Exp. 1a were used in a cross-experiment comparison.

Apparatus and Procedure

The apparatus and procedures were identical to Exp. 1a for the *video 6x group* except that the *video 3x* group was only shown each set of target actions three times on video instead of six times.

Coding and Reliability

Coding of looking time and imitation of target actions for the *video 3x* group was identical to Exp. 1a. Based on

58% of the demonstration sessions, a Pearson product-moment correlation yielded an interobserver reliability coefficient of .94. Based on 91% of test sessions, inter-observer reliability for the imitation score was 95.5% (Kappa = .90).

RESULTS AND DISCUSSION

Preliminary Analyses

Preliminary analyses revealed that there were no main effects of gender, experimenter, or order on outcome, so data were collapsed across these variables for all subsequent analyses.

Demonstration Session

Percent looking time to the *live 3x* (Exp. 1a) and *video 3x* demonstration was high (94.9%, $SE = 1.0$ and 96.5%, $SE = 1.1$, respectively). A between-subjects *t*-test indicated that there was no significant difference between the *live 3x* and *video 3x* groups, $t(22) = 1.08$, *n.s.*, with infants in the *live 3x* and *video 3x* groups looking for an equivalent period of time.

Test Session

A three (Group: *live 3x*, *video 3x*, *baseline*) between-subjects ANOVA was conducted across overall imitation score. As shown in Figure 1 (*video 3x* group), there was a main effect of Group, $F(2, 33) = 35.89$, $p < .0001$ and a large effect size, $d = 1.3$ (Kirk, 1995). Post-hoc SNK tests ($p < .05$) examining the main effect of group showed that the *live 3x* and *video 3x* groups had significantly higher imitation scores than the *baseline control* group. Consistent with prior research, however (Barr & Hayne, 1999; Hayne et al., 2003), the *video 3x* group score was significantly lower than the *live 3x* group. That is, 21-month-olds showed a video deficit effect. This finding confirms that repeated exposure enhanced imitation performance in Exp. 1a.

EXP 1C: CAN 12-MONTH-OLDS IMITATE FROM TELEVISION?

According to published data (Meltzoff, 1988), 14-month-olds are the youngest infants to have exhibited deferred imitation from television. Recent research has shown that, under some conditions, infants as young as 6 months of age will exhibit deferred imitation of behavior modeled live (Barr et al., 1996, 2005; Barr & Hayne, 1999; Barr, Vieira, & Rovee-Collier, 2002; Barr, Vieria, & Rovee-Collier, 2001; Collie & Hayne, 1999; Hayne, Boniface, & Barr, 2000; Hayne, MacDonald, & Barr, 1997). The earliest age at which infants will imitate similar behaviors seen on television is not known. Our pilot data suggested that this is due to the lack of an appropriate task rather than an inability to imitate from television per se.

To determine if it is possible to assess learning from television by 12-month-olds, we tested 12-month-olds in a live group after no delay using the same stimuli as the 15- to 21-month-olds. We found that infants did not imitate the target actions on the wooden animal stimulus set. However, both our pilot data and our observations suggested that the animal apparatus was too big for 12-month-olds to manipulate. We thought it prudent to examine this further and a miniature version of the animal apparatus was constructed. We found that while making the animal toy smaller did increase imitation following a live demonstration of the wooden animal target actions, it also increased baseline performance.

It should be noted that the rattle and wooden animal tasks were based on tasks developed by Bauer (1992). Previously Bauer and colleagues had demonstrated that enabling events that must be assembled in the correct order to achieve the goal (such as the rattle) are learned earlier than the arbitrary events that can be assembled in any order (such as the wooden animal task; Wenner & Bauer, 1999). As such, the fact that 12-month-olds were not imitating the wooden animal task was consistent with prior findings.

Closer examination of the data revealed, however, that infants were performing significantly above baseline on the rattle task after three demonstrations when tested immediately after a live demonstration. The goal for the present study was to test 12-month-olds to examine whether they would imitate the rattle target actions after a 24 hr delay from a live or video model. We replicated Exp. 1a with the rattle stimuli alone assigning 12-month-olds to *live 3x*, *video 6x*, and *baseline control* groups. We predicted that the performance of the *live 3x* group and *video 6x* group would not differ and would exceed the baseline control group. These data would provide evidence of deferred imitation from television by infants under 14 months of age.

METHOD

Participants

Participants were 36 full-term, healthy 12-month-olds (17 girls, 19 boys) recruited as before with a mean age of 383.6 days ($SD = 9.6$). Infants were African-American ($n = 1$), Latino ($n = 4$), Asian ($n = 6$), and Caucasian ($n = 31$). Their parents's mean educational attainment was 16.3 years ($SD = 1.0$), and their mean rank of socioeconomic status (Nakao & Treas, 1992) was 77.0 ($SD = 16.0$). Attrition was low: one infant were excluded from the sample for refusal to touch the stimuli at test.

Apparatus and Procedure

The red and green rattle stimuli were included in this study (see Table 1). Each infant was presented with one of the two rattles. The infants were randomly assigned to *live 3x*, *video 6x*, and *baseline control* groups and tested after a 24 hr delay. As before the total demonstration time for each set of stimuli was on average 30 to 40 s ($M = 35.0$ s, $SD = 6.2$) for the *live 3x* condition.

Coding and Reliability

Coding of looking time and imitation of target actions for the rattle task was identical to Exp. 1a. Looking time could not be coded for one participant because his eyes were not visible on the videotape. Based on 75% of the demonstration sessions, a Pearson product-moment correlation yielded an interobserver reliability coefficient of .91. Based on 42% of the test sessions, interobserver reliability for the imitation score was 97.9% (Kappa = .94).

RESULTS AND DISCUSSION

Preliminary Analyses

Preliminary analyses revealed that there were no main effects of gender, experimenter, or stimulus on outcome, so data were collapsed across these variables for all subsequent analyses.

Demonstration Session

Percent looking time to the *live 3x* demonstration and the *video 6x* demonstration was high (96.9%, $SE = .97$ and 91.49%, $SE = 2.28$, respectively). A between-subjects *t*-test indicated that there was, however, a significant difference between the *live 3x* and *video 6x* groups, $t(21) = 2.25$, $p < .04$ with infants in the *live 3x* group looking significantly longer during the entirety of the demonstration than infants in the *video 6x* group. It is important to note, however, that there was no difference between the amount of time that infants looked during the presentation of the target actions in either group, $t(21) = 1.63$, *n.s.*, (96.9% (*SE*, 1.3) and 93.1% ($SE = 2.0$) for the live and video groups, respectively). It is also important to note that the video was twice as long as the live demonstration and, that overall, infants in the video group were looking for 55.9 s ($SE = 1.2$) and for 29 s ($SE = .4$) in the live group. The longer video did decrease overall percent looking time, but it was marginally less and was not different during the demonstration of the target actions.

Test Session

A 3 (Group: *live 3x*, *video 6x*, *baseline*) between-subjects ANOVA was conducted across overall imitation score. As shown in Figure 1 (left panel), there was a main effect of Group, $F(2, 33) = 3.94$, $p < .03$ and a medium effect size, $d = .40$ (Kirk, 1995). To examine the main effect of Group, post-hoc SNK tests ($p < .05$) showed that there was no significant difference between the live and video groups and that both groups had significantly higher imitation scores than the baseline control group. Overall, Exp. 1c revealed that given the appropriate task, 1-year-olds were able to imitate from television. Recent data from our laboratory (Barr, Garcia, & Muentener, 2006) suggest that 12 months may not be the lower age limit.

GENERAL DISCUSSION

In three experiments, infants aged 12- to 21-months exhibited deferred imitation from both a live and televised model after the number of target actions demonstrated on television were doubled to six demonstrations. If the duration of the target actions presented on video was the same as that presented during the live demonstration, 21-month-olds continued to exhibit a *video-deficit effect* (Exp. 1b). These findings are consistent with research on the effects of repeated presentation on attention and comprehension levels in preschoolers (Crawley et al., 1999; Skouteris & Kelly, 2006). Infant looking patterns during exposure to the target actions were examined systematically for the first time using an imitation paradigm. We found that looking time was consistently high during the video demonstration sessions even though the video demonstration was twice as long as the live demonstration. Prior work conducted by Anderson and colleagues, predominantly with preschoolers, has demonstrated that children's visual attention to television reflects their comprehension of the content of the material presented (Anderson et al., 1981; Field & Anderson, 1985; Lorch et al., 1979). The fact that looking time was maintained and imitation performance between live and video presentations was equated suggests that infants comprehended the imitation task when it was presented on television. Taken together, the present findings suggest that previous laboratory work (e.g., Barr & Hayne, 1999) may have underestimated infants' ability to learn from television.

The fact that such a small change in exposure duration facilitated the performance rate of the 12- to 21-month-olds is consistent with the perceptual impoverishment encoding hypothesis that fewer details are encoded from 2D representations than from 3D representations (see also Anderson & Pempek, 2005; Hudson & Sheffield, 1999;

Schmitt & Anderson, 2002; Suddendorf, 2003). That is, repetition during the demonstration may have enhanced the perceptual encoding and thus provided additional retrieval cues at the time of test. However, the role that perceptual processing plays in the encoding of 2D information is not clear. The present data do not allow us to disentangle whether perceptual encoding problems arise from an impoverished 2D input or the cognitive load due to transferring information from a 2D demonstration to a 3D object. We are currently exploring such a possibility using touch screen technology and attempting to disentangle the effects of impoverished 2D cues at encoding and the ''translation'' difficulty.

There is however, a competing explanation for these data based on a social contingency argument. In the present study the demonstration durations for the live groups varied. These differences may have been due to the fact that the experimenters in the live condition inadvertently paced the demonstration to each individual infant, and the demonstration was in part contingent upon the infant's nonverbal behavior. It should be noted that these differences were small and did not impact either looking time or behavior scores. Unlike live demonstrations, the duration of prerecorded video demonstration was not contingent upon the infant's behavior. Research with older toddlers and preschoolers has demonstrated that lack of contingency reduces levels of interactivity and comprehension of televised material (Calvert, Strong, Jacobs, & Conger, in press; Crawley et al., 1999; Troseth, 2003; Troseth, Saylor, & Archer, 2006). Troseth and colleagues, for example, found that if an experimenter provided contingent information during a 5-min online interaction, then 2-year-olds were significantly more likely to use the online experimenter's information about where to find a hidden toy than toddlers who had seen a pretaped interaction. Troseth et al. conclude that during the second year of life, toddlers increasingly expect to obtain relevant information from a contingent social partner and lack of contingency during the televised demonstration disrupts the processing of information presented on television. We have also found task-related differences in the effectiveness of repetition on imitation from television and have argued that these differences may be associated with the degree of social contingency involved in the task (Barr et al., 2006; see also Crawley et al. for a similar argument). It is important to note that Meltzoff (1988) did not find a video deficit effect in 14-month-olds in the video condition. There are two possibilities for his findings. First, the one-step sequence was not affected and only more complex multi-step sequences result in a video deficit. Alternatively, it is because his study involved a closed-circuit presentation rather than a video demonstration (but see Huang & Charman, 2005). Particularly because of the increasing use of webcam technology to communicate, the use of close-circuit technology could be very useful in furthering our understanding of the role of social contingency on learning from screens.

Explanations based on social contingency fit more closely with the dual representation theory. DeLoache and colleagues proposed that the ability to transfer information from a symbol to the real context involves forming a dual representation (DeLoache, 1987, 1991, 1995; Pierroutsakos & DeLoache, 2003; Troseth, 2003; Troseth, Pierroutsakos, & Deloache, 2004). That is, the child must hold the image of the picture both as an object and as a symbol for the real object in order for transfer to occur. Beginning around 5 months of age, when independent reaching develops and manual exploration begins, infants treat images and objects in very similar ways, attempting to explore both as physical objects to determine their properties. With tactile experience, infants come to recognize the different functional properties of 2D and 3D objects. The lack of social contingency during video demonstration is a key functional difference that toddlers begin to appreciate between 2D and 3D demonstrations. According to the dual representation theory, the more experience infants have with the socially noncontingent functional properties of television, the less they should respond to it. Based on this acquired knowledge, DeLoache and colleagues argue that toddlers aged between 1 and 2.5 years find it cognitively difficult to match information presented on television to real world situations, producing a video deficit effect. The present findings and those of some object search tasks (e.g., Schmitt & Anderson, 2002; Suddendorf, 2003; Troseth, 2003; Troseth et al., 2006) show that amelioration of the video-deficit effect is possible. A more complete theoretical understanding of learning from television will likely involve components of both the perceptual encoding impoverishment and the dual representation theories.

While these data are compelling, there are a number of future studies that might help clarify the findings. In the present study, we examined brief 2 min video segments unaccompanied by narration. Recently, we examined looking time patterns over a longer presentation period using commercially available programming (Barr, Zack, Garcia, & Muentener, 2006). We found that looking times were high and that parents narrate during video viewing (Barr et al., 2006), scaffolding the presentation in a similar way to how they scaffold book reading (e.g., DeLoache & DeMendoza, 1987). We are now experimentally manipulating the content of the televised and parental narration during demonstrations sessions.

Finally, our televised presentations were experimental and therefore did not include many of the typical formal visual and auditory features that accompany commercial television, except for using close-ups of the stimuli and for having a different experimenter on the televised demonstration than in the infant's home. Interestingly, Hayne and colleagues (2003) found that the video deficit effect was not influenced by either a change in experimenter or lack of close-ups during demonstration. Because we systematically examined the demonstration session, we observed that pacing was slightly different, and in particular slower, during live demonstrations than during the video demonstrations. This finding leads to a testable hypothesis that the *video-deficit effect* could also be ameliorated with fewer video demonstrations presented at a slower rate. For elementary school children, low pace appears to be most effective at enhancing story comprehension (Wright et al., 1984). It is not yet clear what sort of pacing would most benefit infants. Future studies should systematically examine the effects of pacing, visual cuts, pans, and close-ups, auditory sound effects, and music on subsequent imitation from television.

These findings already have important practical implications for our understanding of the potential role of technology in learning during infancy in the home environment. Naturalistic studies show that young children typically repeatedly view videotapes (Mares, 1998), and the present findings suggest that repeated videotape viewing may increase infants' and young children's comprehension of media content. These findings are particularly relevant given a recent increase in commercially available infant-directed programming and a subsequent increase in television exposure during infancy. During the 1970s children were first exposed to television on a regular basis at approximately 2.5 years (Anderson, Field, Collins, Lorch, & Nathan, 1985; Anderson & Levin, 1976; Anderson, Lorch, Collins, Field, & Nathan, 1986). Since then, however the media landscape has changed. During the 1990s television programs such as *Teletubbies* and videos/DVDs such as *Baby Einstein* started to be produced specifically for infants. This has shifted the age of regular exposure. A recent nationwide survey of 1000 homes with children aged 0 to 6 years conducted by the Kaiser Family Foundation reported that many infants begin consistently viewing videos/DVDs at 6 to 9 months of age; 74% are exposed to television before age 2 and those exposed to television spend approximately 2 hr per day with television and prerecorded videos and DVDs (Rideout et al., 2003). Furthermore, 58% of parents believed that early exposure to educational television programming was "very important" (Rideout et al., 2003).

Taken together, the present findings suggest that effective learning from television may be possible during the second year of life given the appropriate media content. Such learning may have long-lasting effects. Exposure to high quality programming during the preschool years facilitates later academic performance during adolescence (Anderson, Huston, Schmitt, Linebarger, & Wright, 2001) and conversely exposure to violent programming during preschool increases aggressive behavior during adolescence (Eron, Huesmann, Lefkowitz, & Walder, 1972; Paik & Comstock, 1994). How these data eventually get translated into practice will have important implications for learning in a world where media increasingly pervades infants' lives.

NOTES

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