Music interferes with learning from television during infancy

Article *in* Infant and Child Development · May 2010

DOI: 10.1002/icd.666

5 authors, including:


Rachel Barr
Georgetown University


Lauren H. Howard
Franklin and Marshall College


Emily Elizabeth Atkinson
Johns Hopkins University


Deborah Linebarger
Purdue University

Infant and Child Development
Inf. Child. Dev. **19**: 313–331 (2010)
Published online 8 February 2010 in Wiley InterScience
(www.interscience.wiley.com). DOI: 10.1002/icd.666

Music Interferes with Learning from Television during Infancy

Rachel Barr[a,*], Lauren Shuck[a], Katherine Salerno[a], Emily Atkinson[a] and Deborah L. Linebarger[b]
[a]*Department of Psychology, Georgetown University, Washington, DC, USA*
[b]*Annenberg School for Communication, University of Pennsylvania, Philadelphia, PA, USA*

Infants are frequently exposed to music during daily activities, including free play, and while viewing infant-directed videotapes that contain instrumental music soundtracks. In Experiment 1, an instrumental music soundtrack was played during a live or televised demonstration to examine its effects on deferred imitation by 6-, 12-, and 18-month-old infants. Transfer of information was indexed *via* deferred imitation of the target actions following a 24-h delay. For half the infants, the music context was also reinstated at the time of test. Performance by experimental groups was compared to that of a baseline control group that participated in the test session without prior exposure to the demonstration. Imitation performance was above baseline for the live groups but not for the video groups regardless of age or the music context at test. In Experiment 2, we added matched sound effects to the video demonstration and infants performed above baseline. We conclude that the music track creates additional cognitive load, disrupts selective attention to the target actions and inhibits transfer of learning from television of the imitation task. Music may impair an infant's ability to translate information from a two-dimensional to three-dimensional world even if the auditory context remains the same. Copyright © 2010 John Wiley & Sons, Ltd.

Key words: imitation; television; infancy; music; video deficit

Increasingly, television has become a socializing agent during infancy for children in the Western world. Music content is a staple of many of these programmes and commercial videos developed for very young audiences. During the 1990s, television programmes such as *Teletubbies*® and videos/DVDs such as *Baby Einstein*® created specifically for infants debuted. This change in media availability has shifted the age of regular exposure downward. Many

*Correspondence to: Rachel Barr, Department of Psychology, Georgetown University, 306A White-Gravenor Hall, 3700 O St., NW, Washington, DC 20057, USA. E-mail: rfb5@georgetown.edu

infants begin consistently viewing videos/DVDs between 6- and 9-months of age; 74–90% are exposed to television before age 2; and those exposed spend approximately 1 h per day with the screen media, predominantly television and prerecorded videos and DVDs (Rideout & Hamel, 2006; Rideout, Vandewater, & Wartella, 2003; Zimmerman, Christakis, & Meltzoff, 2007a, b).

Exposure to high-quality preschool educational programmes that often have high music content (e.g. *Sesame Street, Blues Clues,* and *Mister Rogers Neighborhood*) have enhanced preschooler's cognitive (Ball & Bogatz, 1970; Bogatz & Ball, 1971; Wright *et al*., 2001), language (Rice, Huston, Truglio, & Wright, 1990), and prosocial (Stein & Friederich, 1975) skills and have had a long-lasting positive impact on school performance (Anderson, Huston, Schmitt, Linebarger, & Wright, 2001; Wright *et al*., 2001). To date, however, there has been very limited research about the transfer of learning from television to the real world during infancy and in particular little research examining the role that music might play in such transfer of learning.

Video Deficit Effect

Empirical research using a number of different experimental paradigms have demonstrated that infants, toddlers, and preschool children learn less from television than from face-to-face interactions (Anderson & Pempek, 2005; Barr & Hayne, 1999; Barr, Muentener, & Garcia, 2007a; Barr, Muentener, Garcia, Fujimoto, & Chavez, 2007b; Deocampo & Hudson, 2005; Flynn & Whiten, 2008; Hayne, Herbert, & Simcock, 2003; Hudson & Sheffield, 1999; Krcmar, Grela, & Lin, 2007; Kuhl, Tsao, & Liu, 2003; McCall, Parke, & Kavanaugh, 1977; Mumme & Fernald, 2003; Schmitt & Anderson, 2002; Sell, Ray, & Lovelace, 1995; Sheffield & Hudson, 2006; Strouse & Troseth, 2008; Suddendorf, Simcock, & Nielsen, 2007; Troseth, 2003; Troseth & DeLoache, 1998). This has been termed the *video deficit effect:* infants' ability to transfer learning from television to real-life situations is relatively poor in comparison to their transfer of learning from a live demonstration (Anderson & Pempek, 2005). In the case of imitation studies, beginning around 6 months of age, infants can imitate limited actions demonstrated by videotaped models (Barr *et al*., 2007a). The video deficit for imitating from 2D displays peaks around 15 months and persists until approximately 3 years and perhaps beyond depending on task complexity (Barr & Hayne, 1999; Barr *et al*., 2007a, b; Flynn & Whiten, 2008; Hayne *et al*., 2003; Hudson & Sheffield, 1999; Klein, Hauf, & Aschersleben, 2006; McCall *et al*., 1977; Strouse & Troseth, 2008). In Barr and Hayne (1999), a live model showed 12-, 15-, and 18-month-olds three demonstrations and 24 h later infants of all ages imitated the target actions. Only 18-month-olds, however, imitated after three videotaped demonstrations, and their performance was inferior to the live group. Using the same imitation procedures, Hayne *et al*. (2003) found that decrements in learning persist for 30-month-olds. The video deficit effect can, however, be ameliorated by repeating the target actions (Barr *et al*., 2007a, b), by adding language cues (Barr & Wyss, 2008), and by adding social interaction cues (e.g. Nielsen, Simcock, & Jenkins, 2008; Troseth, Saylor, & Archer, 2006).

Formal Features of Television

Learning from television may have been underestimated because prior experimental studies of imitation from television have failed to incorporate typical attention-capturing formal features into their experimental stimuli (e.g.

DOI: 10.1002/icd

Barr *et al*., 2007a, b; Barr & Hayne, 1999; Hayne *et al*., 2003; Hudson & Sheffield, 1999; McCall *et al*., 1977; Meltzoff, 1988). Formal features are the auditory and visual production and editing techniques characterizing television, such as action, sound effects, and pacing (i.e. the rate of scene and character changes). Some features, such as sound effects and lively music, are perceptually salient and likely to elicit attention and interest, whereas other features such as dialogue are not salient but important in processing the narrative (Huston & Wright, 1983).

Recently, Barr, Wyss, and Somanader (2009) examined whether adding sound effects to video or live demonstrations would influence imitation by 6-, 12-, and 18-month-old infants. The 6-month-olds reproduced the target actions from a televised demonstration regardless of whether the sound effects were matched or mismatched to the target actions, but 12- and 18-month-olds reproduced the actions only when the sound effects were matched. When sound effects were added to live demonstrations, however, learning was impaired at all ages. These findings suggested that older infants were using the sound effects as perceptual markers during video demonstrations but that they could also interfere with learning when used in a context that typically does not contain sound effects.

Music, like language, is highly complex, highly attractive to infants, and can also play a very important social role (for review, see Trehub, 2003). For example, lively, simple rhythms direct attention during face-to-face interactions (Trainor, 1996). Infants prefer consonant (a more pleasing combination of tones to adults) rather than disconsonant music (Zentner & Kagen, 1998). During the first year of life, infants also discriminate novel melodies from familiar melodies (e.g. Trehub, Bull, & Thorpe, 1984). Furthermore, Saffran, Loman, and Robertson (2000) found that 7-month-olds remembered musical passages for 2 weeks, particularly when they were presented in musical contexts; that is, remembering the beginning better than the middle of previously familiarized music passages. Lively music during preschool and infant-directed television programmes also consistently produces high levels of looking during infancy (Anderson & Levin, 1976; Barr, Zack, Garcia, & Muentener, 2008).

Music as Context

Literature examining learning from music and learning from television suggest that the auditory context is important (Barr *et al*., 2009; Saffran *et al*., 2000). Music soundtracks could serve as a bridge crossing platforms from the 2D presentation to the 3D real-world setting. Often a baby will hear the same song delivered by a CD, a video, or by a parent. As such, music could facilitate information transfer among different media. This potential for music to transfer information across different media platforms is well recognized but not well investigated. Previous studies have shown that music can set the context for learning and act as a reminder even after forgetting has occurred (Fagen, Prigot, Carroll, Pioli, Stein, & Franco, 1997). In one study conducted by Fagen *et al*. (1997), 3-month-olds learned to move a mobile by kicking. While learning the game, either jazz or classical music was played in the background. Two weeks later, after they had forgotten the game, the infants were given a brief reminder of either the music heard during the demonstration or novel music not heard during the demonstration. The authors found that those who heard a reminder of familiar music that matched the original learning conditions remembered the game at test, while those who heard novel music did not. This is compelling evidence that

DOI: 10.1002/icd

music, even if it is played in the background, provides an auditory context that can act as a retrieval cue early in infancy.

If the music context is not matched between encoding and retrieval, however, music could interfere with learning. That is, if the context of learning is changed between the video presentation and live test, with music occurring during the video but not in the real world, mismatching retrieval cues may interfere with imitation performance. Any such discrepancy between the encoding and retrieval cues is at the core of Hayne's (2004) representational flexibility hypothesis. Early in development, successful memory performance is highly dependent on an exact match between the cues present at the time of encoding and the cues available at retrieval. A mismatch between the nature of the objects present at learning and at testing can disrupt performance. However, memory performance becomes more flexible across development, with older participants increasingly tolerating differences between the conditions at encoding and retrieval. This hypothesis has been supported empirically with infants using operant conditioning procedures (Hartshorn *et al.*, 1998; Hayne & Findlay, 1995; Hayne, Rovee-Collier, & Perris, 1987) and with toddlers using imitation paradigms (Barnat, Klein, & Meltzoff, 1996; Hanna & Meltzoff, 1993; Hayne *et al.*, 2003; Hayne, Boniface, & Barr, 2000; Hayne, MacDonald, & Barr, 1997; Herbert & Hayne, 2000). Thus, adding music at the time of the test may increase the number of retrieval cues that specifically match the original encoding conditions. Alternatively, music may interfere with learning simply because it introduces additional cognitive load to an already complex representational task. Processing music is complex and taxing for the brain and may recruit too many cognitive resources. In the current study, cognitive overload is more likely to occur during the more challenging video conditions than the live demonstration conditions.

The Present Study

Utilizing the fact that infants are prolific imitators, we first demonstrated a well-investigated puppet game and 24 h later, we tested whether they imitated actions previously modelled live or on television. We operationally define performance above baseline as indicative of learning (see Barr & Hayne, 2000). We had two primary research questions: (i) Experiment 1: Can 6-, 12-, and 18-month-old infants imitate from video if a music soundtrack is added and do the conditions of encoding and test influence imitation performance? (ii) Experiment 2: Can 6-, 12-, and 18-month-old infants imitate from a video demonstration if sound effects and a music soundtrack are added to the demonstration? In Experiment 1, we tested two hypotheses, (i) due to the increased perceptual salience of the music soundtrack, matching music context will have a facilitative effect on imitation performance with *music demonstration+test* groups outperforming *music demonstration only* groups and (ii) alternatively, due to the lack of contingent overlap between the soundtrack and the target actions, music will increase the cognitive processing load and interfere with learning, particularly for the video groups, when learning conditions are more challenging. To test these hypotheses we assigned participants to a 2 (group; *music demonstration only* or *music demonstration+test*) $\times$ 2 (presentation mode; *live, video*) fully crossed design and compared performance to baseline levels. For half the infants, music was played during the demonstration and during the imitation recall test (*music demonstration+test* group). For the other half of infants, music was played during the demonstration but not during the test (*music demonstration only* group; see

DOI: 10.1002/icd

Table 1. Placement of the music soundtrack during the demonstration and test phases in Experiments 1 and 2

Experimental condition	Demonstration	Test
Experiment 1		
Music demonstration only	Music	No music
Music demonstration+test	Music	Music
No music	No music	No music
Music baseline	—	Music
No music baseline	—	No music
Experiment 2		
Music+sound effects	Music+sound effects	No music

Table 1). Half the baseline participants heard the same music track during the test (*music baseline*) and half did not (*no music baseline*) to equate their test conditions to those of the *music demonstration+test* and *music demonstration only* experimental groups, respectively. We also conducted a cross-experiment comparison using data collected by Barr *et al.* (2007a) to assess whether music presented during demonstration or demonstration and test facilitated or interfered with learning relative to *video no music* and *live no music* experimental groups. In Experiment 2, we tested the hypothesis that selective attention to the target actions could be enhanced by adding both the music soundtrack and sound effects matched to the target actions to the video demonstration (*music+sound effects*). We conducted a cross-experiment comparison using data from Experiment 1 (*video music demonstration only*) and Barr *et al*. (2007a; *video no music*).

METHOD

Participants

The final sample consisted of 198 infants (66 6-month-olds, 66 12-month-olds and 66 18-month-olds; 89 boys, 109 girls) recruited from commercial mailing lists and by word-of-mouth, all of whom were randomly assigned to the *video music demonstration only, video music demonstration+test, live music demonstration only, live music demonstration+test, music baseline* and *no music baseline* groups. The 6-month-olds had a mean age of 6 months, 15 days (S.D. = 10 days), the 12-month-olds had a mean age of 12 months, 15 days (S.D. = 9 days) and the 18-month-olds had a mean age of 18 months, 15 days (S.D. = 10 days). Participants were African-American ($n = 5$), Asian ($n = 7$), Caucasian ($n = 145$), Latino ($n = 13$), or Mixed race ($n = 23$); five families did not report. The parents' mean educational attainment was 17.58 years (S.D. = 1.05), and the mean rank of socioeconomic index (SEI, Nakao & Treas, 1992) was 79.03 (S.D. = 12.73) reported by 90.4% and 96.0% of the sample, respectively. Educational attainment, occupational status, and annual income are the major components of socio-economic status. The SEI ranks 503 occupations listed in the 1980 US census on a scale of 1–100, with higher status occupations (e.g. physician) being accorded higher ranks (Nakao & Treas, 1992). Testing was discontinued on additional infants for refusal to touch the stimuli at test ($n = 9$), excessive crying ($n = 5$), refusal to sit during test ($n = 3$), less than 50% attention during the demonstration ($n = 3$), maternal interference ($n = 1$), equipment failure ($n = 7$), or experimenter error ($n = 18$).

Using a partial replication approach, a pooled *no music baseline* was created by including 18 additional, age-matched, no music baseline control infants (6 infants at each age) that used the same stimuli and experimental procedures from our most recently published study (Barr *et al*., 2009). These infants did not see a demonstration of the target actions prior to the test and no music accompanied the test. There was no difference between the baseline scores of the no music baseline group and the previously collected no music baseline data $t(34) < 1$; therefore, these data were collapsed for subsequent analyses.

Data from Barr *et al*. (2007a) were also used to gain a cross-experiment comparison group of infants who observed actions presented without music during either the live or the video demonstration or the test session. The demographics of the Barr *et al*. (2007a) *live no music* and *video no music* groups were also very similar to infants in the *live* and *video music demonstration only and live* and *video music demonstration+test* groups. The 6-month-olds had a mean age of 6 months, 19 days (S.D. = 7.8 days), the 12-month-olds had a mean age of 12 months, 15 days (S.D. = 8.7 days) and the 18-month-olds had a mean age of 18 months, 15 days (S.D. = 7.2 days). Participants were African-American ($n = 3$), Asian ($n = 8$), Caucasian ($n = 45$), Latino ($n = 9$), Native American ($n = 1$), or of Mixed race ($n = 5$), and one family did not report. The parents' mean educational attainment was 17.0 years (S.D. = 1.1), and the mean rank of socioeconomic status (Nakao & Treas, 1992) was 75.2 (S.D. = 17.0) reported by 95.8% and 90.3% of the sample, respectively.

Apparatus

Four hand puppets (a pastel pink rabbit, a pale grey mouse, a black-and-white cow, and a yellow duck) were constructed for use in the current experiments and were not commercially available. All puppets were 60 cm in height and were made of soft, acrylic fur. A removable felt mitten (8 cm × 9 cm) was placed over the right hand of each puppet. The mitten was pink, grey, black, or yellow and matched the color of the rabbit, mouse, cow, or duck, respectively. During the demonstration session, a large jingle bell was secured inside the mitten. The puppet type (rabbit, mouse, cow, or duck) was counterbalanced within groups.

Four professionally produced 60 s video segments, two for each stimulus, containing a sound track, were made for the study. The sound track was chosen from a commercial production library providing 'canned music' for use in Audiovisual productions. The soundclip used in the stimulus was from the disc KT 70 'Children Volume 1', track 11, entitled 'Clubhouse Capers', composed by Kevin Klingler. The music clip is a single repeated measure in 4/4 time in a major key with a tempo of approximately 140 beats per min. The rhythm is a quarter note, followed by a dotted eighth and sixteenth, then two additional quarter notes. The second and fourth beats consist of the same major triad and the 'base line' is comprised of the first and third beats, with the third beat a fourth below the first. The music sounds 'child-friendly' due to the simplicity of the line, the major key, the swing to the rhythm, and the upbeat rhythm. In each video segment, the puppet was centred in the middle of the screen and was filmed at a close range. Similar to the live demonstration, the adult model's hands and arms were visible throughout the presentation. The face of the experimenter was only partially visible because the puppet was placed in front of his face. The segments were recorded onto both videotapes and DVDs. The same soundtrack was played on a portable CD player during the live music demonstrations, during the music demonstration+test video and live tests, and during the music baseline test.

DOI: 10.1002/icd

Procedure

Infants were tested in their own homes at a time when parents reported they were most likely to be awake and alert. This time varied across infants but remained relatively constant across both demonstration and test phases for the same infant. Infants in the video groups viewed the demonstration on their own televisions. Family television screens ranged from 26 to 132 cm ($M = 67$ cm, S.D. = 22) across the diagonal. All sessions were videotaped for later analysis.

Demonstration session

Infants in video music demonstration only, video music demonstration+test, live music demonstration only and live music demonstration+test groups participated in this session. An experimenter demonstrated three specific actions on the puppet 6 times in succession on videotape/DVD for the video groups or 3 times in succession live for the live groups (except the 6-month-olds who saw six demonstrations; see Barr, Dowden, & Hayne, 1996; Barr *et al.*, 2007). All experimental conditions were accompanied by the music soundtrack. There was an equal delay between the pressing of the DVD or the CD player and the beginning of the music soundtrack. That is, in both conditions after a brief pause music begins and then an experimenter (either live or on video) begins a demonstration with a puppet. Both the caregiver and the experimenter directed the infant's attention to the television screen or the live demonstration using the child's name and the word 'look' but did not describe the target actions.

The puppet target actions lasted a total of 52 s and the entire video demonstration, allowing for the experimenter to narrate standard phrases and say hello and goodbye, lasted 65 s. For the video groups, the music soundtrack was professionally added to the videotaped recording. The caregiver and infant were seated approximately 80 cm from the family's own television, set such that the screen was at the infant's eye level but out of reach. The video started after the infant and caregiver were correctly positioned. To increase the ecological validity of the study, the video model was not present in the home because infants do not typically meet television presenters.

For the live groups, the experimenter sat on the floor in front of the infant such that the puppet was out-of-reach and demonstrated the target actions. For the live groups, the same soundtrack was played on a portable CD player to control for the sound level, the location, and height of the device (directly behind the experimenter).

Test session

The test session occurred following a 24 h delay. For the *music demonstration+test* and the *music baseline* groups, the soundtrack was played on a portable CD player. For the *music demonstration only* and the *no music baseline* groups the soundtrack was not played. During the test session, there was no bell in the mitten. The experimenter placed the puppet within the infant's reach, and the infant was allowed 90 s (120s for 6-month-olds, see Barr *et al.*, 1996) from the time he or she first touched the puppet to imitate the target actions. Infants in the experimental groups were tested with the same puppet they had seen the day before.

Performance was compared to that of the *no music pooled baseline* and *music baseline* control groups. Infants in the baseline control groups did not participate in the demonstration session. Rather, they were shown the test stimuli for the first

DOI: 10.1002/icd

time during the test session. These control groups were used to assess the spontaneous production of the target actions in the absence of the demonstration.

Coding and Reliability

Demonstration session

Looking time was coded from videotaped sessions using a computer timer. The coder pressed a key to mark the beginning and end of the demonstration and pressed a key when infants looked at or away from the demonstration. The duration of the looks and overall percent looking were subsequently calculated (e.g. Anderson & Levin, 1976). Data were not recorded for four infants due to technical errors. Based on 33.3% of the sessions, intraclass correlations on percent looking time yielded an interobserver reliability coefficient of 0.90.

Test Session

An observer noted the total number of target actions (remove, shake, replace or attempt to replace the mitten) that each infant imitated during the 90 s for 12- and 18-month-olds and 120s for the 6-month-olds from when the infant first touched the puppet (range 0–3). Based on 36.7% of the test sessions, interobserver reliability was 96.8% (Kappa = 0.89). When the two raters differed, the primary rater's score was assigned.

RESULTS

Preliminary Analyses

Preliminary analyses revealed that there were no main effects of gender, stimuli, or TV size on either percent looking time or imitation score so data were collapsed across these variables for all subsequent analyses in both experiments.

Demonstration Session

A 3 (Age) × 4 (Group; video music demonstration only, video music demonstration+test, live music demonstration only, live music demonstration+test) between-subjects ANOVA across percent looking time to the demonstration yielded no main effect of Age, $F(2, 130) = 1.70$, $p = 0.18$, or Group, $F(3, 130) = 1.66$, $p = 0.18$, and no Age × Group interaction, $F(6, 130) = 1.21$, $p = 0.30$ (see Table 2). Overall levels of looking were high. Given the lack of group differences, it seems

Table 2. Percent looking time as a function of the experimental condition

Condition	Mean	S.D.
Experiment 1		
Video music demonstration only	85.19	13.98
Video music demonstration+test	89.26	9.85
Live music demonstration only	87.68	10.83
Live music demonstration+test	90.54	6.54
Experiment 2		
Video music+sound effects	89.22	11.66

DOI: 10.1002/icd

unlikely that differences in looking time can account for subsequent differences in imitation performance as a function of music condition or age.

Test session

The critical question for the present experiment was whether the presence of music during demonstration or during both demonstration and test affected imitation from televised or live demonstrations and whether this differed as a function of age. A 3 (Age) $\times$ 6 (Group; *video music demonstration only, video music demonstration+ test, live music demonstration only, live music demonstration+test, music baseline, no music baseline*) between-subjects ANOVA across imitation score yielded a main effect of Group, $F(5, 198) = 7.53$, $p < 0.001$, partial $\eta^2 = 0.16$, no main effect of Age, $F(2, 198) = 2.19$, $p = 0.11$, partial $\eta^2 = 0.02$, and no Age $\times$ Group interaction, $F(5, 198) < 1$, partial $\eta^2 = 0.04$. As shown in Figure 1, *post-hoc* Student–Newman–Keuls *t*-tests ($p < 0.05$) showed that infants in the *live music demonstration only* and *live music demonstration+test* groups performed significantly above both baseline groups, above the *video music demonstration only* and *video music demonstration+test*, groups, and did not differ significantly from one another. The *video music demonstration only* and *video music demonstration+test* groups did not perform above either baseline group, and did not differ from one another. That is, music disrupted imitation from television but not from live demonstrations. Overall, music disrupted imitation from television across age regardless of whether testing conditions were accompanied by the same soundtrack or not.

To confirm that there was an inhibitory effect of music on imitation performance from television, we conducted a cross-experiment comparison with the *video no music* groups collected by Barr *et al*. (2007a). Once again, we conducted a 3(Age) $\times$ 4(Group; *video music demonstration only, video music demonstration+test, baseline* (*music+no music*) and *video no music*) to assess whether the music had an interfering effect on imitation from television. The between-subjects ANOVA across imitation score yielded a main effect of Group, $F(3, 168) = 11.47$, $p < 0.001$, partial $\eta^2 = 0.17$, no main effect of Age, $F(2, 168) < 1$, and no Age $\times$ Group interaction, $F(6, 168) < 1$. *Post-hoc* Student–Newman–Keuls *t*-tests ($p < 0.05$) showed that infants in the *video no music* groups performed significantly above baseline and above the *video music demonstration only* and *video music demonstration+test*

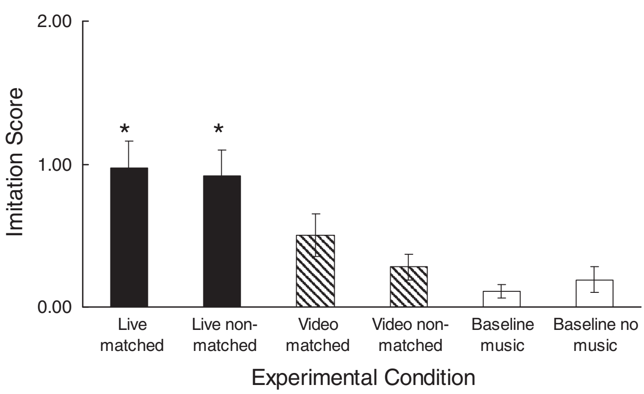

Figure 1. The mean imitation score (± 1 S.E.) as a function of experimental condition. An asterisk indicates that the individual group performed significantly above its matched baseline control condition.

DOI: 10.1002/icd

groups. That is, 6-, 12-, and 18-month-olds could imitate from television when the same video stimuli and test puppets were used but the soundtrack did not accompany either the video or the test session (Barr *et al.*, 2007a) and performance returned to baseline when the music soundtrack was added during the demonstration or was played during the demonstration and test. This analysis suggests that the music was interfering with imitation from television.

The second question to be addressed was whether or not music was interfering with imitation performance following a live demonstration, we conducted a cross-experiment comparison with the *live no music* groups collected by Barr *et al.* (2007a). Once again, we conducted a 3(Age) × 4(Group; *live music demonstration only, live music demonstration+test, baseline (music+no music)* and *live no music*) to assess whether the music had an interfering effect on imitation following a live demonstration. The between-subjects ANOVA across imitation score yielded a main effect of Group, $F(3, 168) = 16.46$, $p<0.001$, partial $\eta^2 = 0.23$, a main effect of Age, $F(2, 168)$ 6.73, $p<0.02$, partial $\eta^2 = 0.07$, and no Age × Group interaction, $F(6, 168)$ 150, *n.s. Post-hoc* Student–Newman–Keuls *t*-tests ($p<0.05$) showed that infants in all the *live experimental* groups performed significantly above baseline but did not differ from one another. Furthermore, 18-month-olds performed significantly above 12-month-olds and 6-month-olds were intermediate between the two. That is, the music did not depress imitation performance following a live demonstration relative to no music at all. Furthermore, we replicated the typical age-related increase in imitation performance (Barr *et al.*, 1996) except that 6-month-olds performed at a slightly higher level than in previous studies.

Experiment 1 established that the music soundtrack interferes with learning from a video demonstration but not a live demonstration. It is possible that the music soundtrack created additional cognitive load such that processing of the visual information was disrupted and likely not encoded. Alternatively, the soundtrack may have disrupted selective attention to the target actions. As mentioned above, Barr *et al.* (2009) demonstrated that sound effects matched to the target actions can influence action understanding (see also Baldwin, Baird, Saylor, & Clark, 2001: Hauf & Aschersleben, 2008; Hauf, Elsner, & Aschersleben, 2004; Klein *et al.*, 2006; for related findings). Experiment 1 findings are in stark contrast to those of previous research on the role of matched sound effects on imitation. It is possible that background music added cognitive load but is not meaningfully related to the target actions. Thus selective attention may be disrupted by the unrelated soundtrack. Therefore, in Experiment 2, we examined whether adding matching sound effects to the video demonstration with a music soundtrack would influence imitative performance.

EXPERIMENT 2: DOES ADDING SOUND EFFECTS TO THE MUSIC SOUNDTRACK IMPROVE IMITATION BY 6-, 12- AND 18-MONTH-OLDS?

Processing of formal features, such as music and sound effects, takes both cognitive skills and experience, and understanding content depends upon comprehension of formal features (Beentjes, de Koning, & Huysmans, 2001). According to the sampling model of attention, during early childhood, attention increases in the presence of a perceptually salient formal feature such as a sound effect because it elicits a primitive orienting response, thereby improving comprehension of contiguously presented content (Calvert & Scott, 1989; Calvert, Huston, Watkins, & Wright, 1982; Huston & Wright, 1983; Rice, Huston,

DOI: 10.1002/icd

& Wright, 1982). The ability to selectively attend to aspects of onscreen content develops with age (Huston & Wright, 1983). Young children use formal features as cues that mark important information because these cues highlight content presented concurrently. Children are poor at distinguishing between incidental and important information on their own; therefore, such formal features could be used to provide an entry point for very young children's viewing. That is, features like sound effects could be used to assist very young children's attention to, and imitation of, targeted content and overcome the video deficit (Barr *et al.*, 2009; Calvert *et al.*, 1982; Rice *et al.*, 1982).

According to common coding theory, it is also possible that the addition of salient sound effects would increase attention and information processing in positive ways because there is a similar representation for action perception and action production (Prinz, 1997; see also Aschersleben, 2006; Meltzoff, 1993). A second major assumption of this theory is that action effects should have large consequences for action production. That is, a salient consequence of an action should be coded and increase the likelihood that the action is reproduced for any given goal-directed sequence. Televised demonstrations provide an avenue to test these assumptions. Barr *et al.* (2009) found that 6-, 12- and 18-month-old infants displayed deferred imitation when the sound effects were matched. In Experiment 1, the music soundtrack may have disrupted infant processing of the target actions because the music did not contiguously match the target actions being demonstrated. In Experiment 2, therefore, perceptually salient sound effects were added to the video demonstration and overlaid with the music soundtrack from Experiment 1. Thus, if disruption to selective attention is related to decreased imitation in the video music groups, we predict that the addition of matched sound effects will increase infants' imitation of the target actions.

Method

Participants

The sample consisted of 57 infants (19 6-month-olds, 19 12-month-olds, and 19 18-month-olds; 25 females and 32 males) recruited from commercial mailing lists and by word of mouth. All participants were randomly assigned to either the *video 6x full mix* group ($n = 12$, with an additional infant in the 6- and 12-month-old groups) or *baseline control* group ($n = 6$, with an additional infant in the 18-month-old group). The 6-month-olds had a mean age of 6 months, 18 days (S.D. = 10 days), the 12-month-olds had a mean age of 12 months, 18 days (S.D. = 9 days), and the 18-month-olds had a mean age of 18 months, 19 days (S.D. = 9 days). Participants were African-American ($n = 2$), Asian ($n = 2$), Caucasian ($n = 39$), Latino ($n = 1$), of mixed ethnic origin ($n = 11$), and two families did not report. The parents mean educational attainment was 17.72 years (S.D. = 0.81), and the mean rank of socioeconomic index (SEI, Nakao & Treas, 1992) was 82.42 (S.D. = 10.69) reported by 87.7% and 89.5% of the sample, respectively. Testing was discontinued on additional infants for less than 50% looking time during the demonstration ($n = 6$), crying during the test session ($n = 1$), refusal to touch the puppet ($n = 2$), equipment failure ($n = 2$), experimenter error ($n = 1$), and parental interference ($n = 1$).

Using a partial replication approach, a pooled baseline was created by including six randomly chosen additional *baseline control* infants at each age from Experiment 1 to make a *pooled baseline control* group of $n = 12$ per age group (for a similar rationale, see Barr *et al.*, 2009).

DOI: 10.1002/icd

Apparatus and procedure

The experimental stimuli were the same as those used in Experiment 1. Four additional professionally produced 60 s video segments were made for the study. Sound effects that matched the target actions were superimposed over the children's cartoon soundtrack used in Experiment 1. There were four separate sound effects (a 0.5 s remove the mitten sound effect, a 0.5 s swoosh for movement across the puppet, a 0.5 s pause, 5 s bell ringing, a 1 s pause, and then a 0.5 s squelch sound for replacing the mitten). The procedure was identical to Experiment 1, except that infants in the *video music+sound effects* group were shown the videotape with sound effects and music during the demonstration session and tested with the same puppet 24 h later. No music played during the test session.

Coding and Reliability

Looking time and imitation scores were coded as in Experiment 1. Based on 44.7% of the demonstration sessions, an intraclass correlation on percent looking time yielded interobserver reliability coefficient of 0.96. Based on 29.3% of the test sessions, the interobserver reliability for imitation score was 93.94% (Kappa = 0.83). When the two raters differed, the primary rater's score was assigned.

RESULTS AND DISCUSSION

Demonstration Session

Percent looking time to the *video music+sound effects* demonstration was high (84.4%, S.E. = 4.64 for 6-month-olds, 88.1%, S.E. = 3.10 for 12-month-olds, and 93.4%, S.E. = 1.31 for 18-month-olds). A one-way between-subjects ANOVA across percent looking time to the demonstration yielded no main effect of age, $F(2, 30) < 1$.

Test Session

In order to examine whether the *video music+sound effects* group increased imitation performance with video demonstrations, we conducted a cross-experiment comparison with the *video no music* group (Barr *et al.*, 2007a) and the *video music demonstration only* group (Experiment 1). We chose the *video music demonstration only* group because it most closely approximates the *video music+sound effects* group in that the children's soundtrack is heard during the demonstration but not during the test. A 3 (Age) × 4 (Group; *video music+sound effects*, *video no music*, *video music demonstration only*, *pooled baseline control*) between-subjects ANOVA across imitation score yielded a main effect of Condition, $F(3, 135) = 10.99$, $p < 0.001$, partial $\eta^2 = 0.20$; no main effect of Age, $F(2, 135) = 1.13$, *n.s.* and no Age × Group interaction, $F(6, 135) < 1$. *Post-hoc* SNK tests ($p < 0.05$) showed that the *video music demonstration only* group did not differ from the *pooled baseline control* group. The SNK tests also showed that infants in the *video no music* and *video music+sound effects* groups performed significantly above baseline but did not differ from one another (see Table 3).

The results show that the addition of matched sound effects to a cartoon soundtrack ameliorated the interference of the music but does not increase imitation performance above the video condition with no music or sound effects added. These findings contrast with Experiment 1 in which none of the

DOI: 10.1002/icd

Table 3. Imitation score (S.E.) as a function of age and experimental condition. Data from Experiment 1 and previous studies included

Condition	Mean	S.E.
Video music+sound effects	0.81	0.28
Video music demonstration only	0.28	0.17
Video no music	0.94	0.26
Pooled baseline control	0.08	0.04

experimental groups imitated from the video demonstration when a cartoon soundtrack had been added. Thus, although the cartoon soundtrack does seem to increase the cognitive load required to encode the demonstration, we conclude that the music is specifically interfering with infants' ability to selectively attend to the target actions. When these visual target actions are made more salient by the addition of sound effects matched to them, infants' performance increases.

GENERAL DISCUSSION

The present study demonstrated that instrumental music may impair an infant's ability to translate information from a 2D source to the real world even if music is played both at demonstration and test. In Experiment 1, we found not only a video deficit but also a complete interference effect; the video music groups did not perform above baseline. Surprisingly, unlike findings using the mobile conjugate reinforcement paradigm (Fagen *et al.*, 1997), the music context did not facilitate transfer of learning from the video to the real-world context. Without the music, infants learn the puppet task at all ages regardless of whether information is presented *via* a live or televised model (Barr *et al.*, 2007a). The findings from Experiment 2 indicated that overlaying sound effects matched to the target actions resulted in imitation performance that returned to the level of the groups who had no sound effects or music added. There were no age-related changes in performance. This is consistent with our previous findings showing that in particular 18-month-olds do not show the age-related increase in performance following a video demonstration (for further discussion see Barr *et al.*, 2007a, 2009). Taken together, the two experiments clearly demonstrate that background music and action-related sound effects have a different impact on infants' action understanding and imitative performance. We conclude that the music track, because it did not provide additional semantic or meaningful information, created additional cognitive load and inhibited information processing of the imitation task when the task was presented on television. This is compelling evidence that music, even if it is played in the background, is not passive but very much an active component of attention, learning, and memory retrieval during infancy. Sound effects, however, allowed for selective attention to the target actions even in the presence of the additional cognitive load of the music soundtrack.

The video deficit may not be due to a perceptual processing problem, but rather, it may reflect the infant's difficulty in integrating perceptual information with action-based information and transferring it to their behavioural repertoire (Barr & Hayne, 1999; Hofer, Hauf, & Aschersleben, 2007; Suddendorf, 2003). Processing information from 2D media may emerge earlier than transferring information from 2D to 3D contexts (Bahrick & Lickliter, 2004; Carver, Meltzoff, &

DOI: 10.1002/icd

Dawson, 2006; Elsner & Aschensleben, 2003; Hofer *et al.*, 2007; Simcock & Deloache, 2006; Zack, Barr, Gerhardstein, Dickerson, & Meltzoff, 2009). For example, Hofer and colleagues (2007) showed that 6-month-old infants perceived goal-directed actions from video as readily as they perceived them from a live demonstration. Furthermore, Zack and colleagues found that whether learning is from 2D or 3D, transfer across dimension is the rate-limiting step in processing for infants (Zack *et al.*, 2009). In a completely crossed design, a target action was demonstrated on a 2D touch screen or a real 3D object and infants were subsequently tested using the 2D touch screen or a 3D object. Infants imitated the target actions when the dimension did not change between demonstration and testing (2D–2D or 3D–3D) but were impaired when a transfer across dimension was required (3D–2D or 2D–3D). Finally, Simcock and Deloache (2006) found that changes in the nature of the stimulus disrupted learning from 2D books. This was particularly evident for 2-year-olds, who required high levels of iconicity in order to imitate from books. Similarly, in the present study, the music soundtrack may be presenting an additional cognitive load without providing additional content cues, resulting in mismatching auditory and visual cues (see also Barr *et al.*, 2009). It is important to note that, for the live conditions, a CD player was used to play the music to reflect how music would typically be played in the home. Although this meant that the music was less integrated with the live demonstration than with the video demonstration, we wanted to maintain high levels of ecological validity. All groups were disrupted under the more challenging transfer task from video to the real world regardless of whether the auditory context was matched or not, suggesting that music at the time of the test did not provide retrieval cues to facilitate transfer. The addition of matched sound effects, even in the presence of the interfering soundtrack, however, potentially enhanced selective attention to the target actions, providing a common perceptually salient matching auditory and visual representation.

Theoretically, changes in working memory could account for the disruption to imitation performance. Krcmar and colleagues (2007) concluded that changes in working memory may be partially responsible for the deficits seen in processing both auditory and visual input and transferring that information from a televised model to a 3D test context. According to these authors, research on working memory suggests that toddlers less than 30 months may have difficulty integrating language, music, and visual information when these streams of information are presented simultaneously (Kcrmar *et al.*, 2007). The authors hypothesized, however, that changing the stimuli may enhance information processing, even with high levels of cognitive load. Future studies could also test the working memory hypothesis by habituating infants to the music soundtrack and then testing them in the presence of music during the demonstration and the test. If they are habituated to the music, the cognitive load required to attend to both the soundtrack and the demonstration of the target actions is reduced; therefore, the disruption to performance may be reduced as well. Finally, studies examining music learning during infancy, including learning in the context of music, are relatively rare (see Saffran *et al.*, 2000). As such, the present study raises a number of questions regarding the musical context *per se*. Future studies should examine whether different types of music or differing amounts of music result in different patterns of learning. Future research should also examine the effects of matching the visual content to the music tempo.

Finally, other researchers have suggested that the lack of social contingency during video demonstrations is a major contributing factor to the video deficit effect. During live interactions, social partners engage in contingent ongoing

DOI: 10.1002/icd

behaviours with one another. Consistent with that argument, research with older toddlers and preschoolers has demonstrated that the lack of contingency reduces levels of interactivity and comprehension of video material (Calvert, Strong, & Gallagher, 2005; Crawley, Anderson, Wilder, Williams, & Santomero, 1999; Flynn & Whiten, 2008; Nielsen *et al.*, 2008; Troseth, 2003; Troseth *et al.*, 2006). There is limited evidence that similar social cues or expectations about interpersonal interactions help young infants and toddlers learn language from televised media (Linebarger & Vaala, 2009; O'Doherty, 2009).

The findings from the present study add to a small but growing body of data indicating that information processing of media content is challenging and improves gradually across infancy and toddlerhood. It is highly likely that the ability to comprehend media content and transfer information stems from the ability to process the formal features such as music soundtracks and sound effects that accompany the content. In some cases it may be necessary to habituate to the extraneous musical information and to highlight visual content by other means, such as perceptually salient sound effects. Our findings also suggest that examining imitation from television may not only inform us about the potential for learning from television during infancy but may also provide some insight into the development of representational flexibility.

The socializing effect of TV may be a particularly Western phenomenon. Daily exposure to children's television featuring music soundtracks that are not semantically linked to programme content may negatively interfere with learning from television. It is not clear whether these findings would generalize to children with little or no exposure to television. Similarly, these data are collected from a largely middle class sample and it is not clear whether or not different patterns of learning would occur for children from other socioeconomic backgrounds or those who are exposed to higher levels of television. While the findings from the present study show that a single exposure to televised content containing background music interfered with learning, it is possible that interference may be reduced with repeated exposure to the music. After single viewing experiences some programmes (i.e., Sesame Street) were associated with poorer language skills but repetitive viewing did shift the relationship with language to a positive association (Linebarger & Vaala, 2008; Linebarger & Walker, 2005).

Studies that directly examine commercially available television and prescribe levels of exposure to specific programmes may give us more experimental insight into the role of specific television exposure and learning. For example, Vandewater, Park, Lee, and Barr (in press) experimentally manipulated commercial video content to assess whether toddlers were able to learn a novel word and match it to a shape from a video clip based on Brainy Baby's® *Baby Shapes* video. Infants were exposed to the programme for 3 months. The experimental group video contained a novel crescent shape and four other more common shapes. The control condition video contained the four common shapes but did not contain the crescent shape. Infants in the experimental condition were significantly more likely to point to the novel crescent shape than infants in the control condition. Groups did not differ, however, on four other more common shapes that were presented in both the experimental and control videos.

From a practical perspective, producers and parents should understand which and how different stimulus factors interfere with or support learning. The fact that instrumental music could interfere with the transfer of learning from television during infancy was a surprising result. The lack of disruption when sound effects matched to programme content were combined with background music indicates that content should be assembled by paying careful attention to the myriad of features in infant-directed media. Producers should make decisions about which of these features are essential and which are superfluous, ultimately ensuring that these features contribute to semantic processing of content. Particular attention should be paid to the music in infant-directed videos given that this may add additional cognitive load when it lacks any meaningful connections to visual and auditory content. Further, sound effects that highlight important visual content can be especially effective when used in these products. Given the ubiquitous nature of videos/DVD accompanied by musical soundtracks, future empirical investigation is needed in order to disentangle how and why interference occurs, and how and why different formal features influence learning.

ACKNOWLEDGEMENTS

A very special thank you to all the families who made this research possible. Support for this research was provided by Grant number HD043047-01 from the National Institute of Child Health and Development to Rachel Barr, Grant number 0126014 to Sandra Calvert from the National Science Foundation and Grant number 9300-71000 to Deborah Linebarger from the Department of Education Ready to Learn Initiative.

REFERENCES

Anderson, D. R., Huston, A., Schmitt, K., Linebarger, D. L., & Wright, J. C. (2001). Early childhood television and adolescent behavior. *Monographs of the Society for Research on Child Development*, *66* (1, Serial No. 264).

Anderson, D. R., & Levin, S. R. (1976). Young children's attention to 'Sesame Street.' *Child Development*, *47*, 806–811.

Anderson D. R., & Pempek, T. (2005). Television and very young children. *American Behavioral Scientist*, *48*, 505–522.

Aschersleben, G. (2006). Early development in action control. *Psychology Science*, *48*, 405–418.

Bahrick, L., & Lickliter, R. (2004). Infants' perception of rhythm and tempo in unimodal and multimodal stimulation: A developmental test of the intersensory redundancy hypothesis. *Cognitive, Affective, and Behavioral Neuroscience*, *4*, 137–147.

Baldwin, D. A., Baird, J. A., Saylor, M. M., & Clark, M. A. (2001). Infants parse dynamic action. *Child Development*, *72*, 708–717.

Ball, S., & Bogatz, G. A. (1970). *The First Year of Sesame Street*: *An Evaluation*. Princeton: Education Testing Service.

Barnat, S. B., Klein, P. J., & Meltzoff, A. N. (1996). Deferred imitation across changes in context and object: Memory and generalization in 14-month-olds. *Infant Behavior & Development*, *19*, 241–252.

Barr, R., Dowden, A., & Hayne, H. (1996). Developmental changes in deferred imitation by 6- to 24-month-old infants. *Infant Behavior and Development*, *19*, 159–171.

Barr, R., & Hayne, H. (1999). Developmental changes in imitation from television during infancy. *Child Development*, *70*, 1067–1081.

Barr, R., & Hayne, H. (2000). Age-related changes in imitation: Implications for memory development. In C. Rovee-Collier, L. P. Lipsitt, & H. Hayne (Eds), *Progress in infancy research* (Vol. 1, pp. 21–67). Mahwah, NJ: Erlbaum.

Barr, R., Muentener, P., Garcia, A. (2007a). Age-related changes in deferred imitation from television by 6- to 18-month-olds. *Developmental Science*, *10*, 910–921.

Barr, R., Muentener, P., Garcia, A., Fujimoto, M., & Chavez, V. (2007b). The effect of repetition on imitation from television during infancy. *Developmental Psychobiology*, *49*, 196–207.

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

Barr, R., Wyss, N., & Somanader, M. (2009). Imitation from television during infancy: The role of sound effects. *Journal of Experimental Child Psychology, 123*, 1–16.
Barr, R., Zack, E., Garcia, A., & Muentener, P. (2008). Infants' attention and responsiveness to television increases with prior exposure and parental interaction. *Infancy, 13*, 30–56.
Beentjes, J. W. J., de Koning, E., & Huysmans, F. (2001). Children's comprehension of visual formal features in television programs. *Journal of Applied Developmental Psychology, 22*, 623–638.
Bogatz, G. A., & Ball, S. (1971). *The second year of sesame street*: *A continuing evaluation* (2 vols.). Princeton: Education Testing Service.
Calvert, S. L., Huston, A. C., Watkins, B. A., & Wright, J. C. (1982). The relation between selective attention to television forms and children's comprehension of content. *Child Development*, *53*, 601–610.
Calvert, S. L., & Scott, M. C. (1989). Sound effects for children's temporal integration of fast-paced television content. *Journal of Broadcasting and Electronic Media*, *33*, 233–246.
Calvert, S. L., Strong, B., & Gallagher, L. (2005). Control as an engagement feature for young children's attention to and learning of computer content. *American Behavioral Scientist*, *48*, 578–589.
Carver, L. J., Meltzoff, A. N., & Dawson, G. (2006). Event-related potential (ERP) indices of infants' recognition of familiar and unfamiliar objects in two and three dimensions. *Developmental Science*, *9*, 51–62.
Crawley, A. M., Anderson, D. R., Wilder, A., Williams, M., & Santomero, A. (1999). Effects of repeated exposures to a single episode of the television program *Blue's Clues* on the viewing behaviors and comprehension of preschool children. *Journal of Educational Psychology, 91*, 630–637.
Deocampo, J. A., & Hudson, J. A. (2005). When seeing is not believing: Two-year-olds' use of video representations to find a hidden toy. *Journal of Cognition and Development*, *6*, 229–258.
Elsner, B., & Aschersleben, A. (2003). Do I get what you get? Learning about the effects of self-performed and observed actions in infancy. *Consciousness and Cognition*, *12*, 732–751.
Fagen, J., Prigot, J., Carroll, M., Pioli, L., Stein, A., & Franco, A. (1997). Auditory context and memory retrieval in young infants. *Child Development*, *68*, 1057–1066.
Flynn, E., & Whiten, A. (2008). Imitation of hierarchical structure versus component details of complex actions by 3- and 5-year-olds. *Journal of Experimental Child Psychology, 101*, 228–240.
Hanna, E., & Meltzoff, A. N. (1993). Peer imitation by toddlers in laboratory, home, and day-care contexts: Implications for social learning and memory. *Developmental Psychology, 29*, 702–710.
Hartshorn, K., Rovee-Collier, C., Gerhardstein, P., Bhatt, R. S., Klein, P. J., Aaron, F., Wondoloski, T. L., & Wurtzel, N. (1998). Developmental changes in the specificity of memory over the first year of life. *Developmental Psychobiology, 33*, 61–78.
Hauf, P., & Aschersleben, G. (2008). Action-effect anticipation in infant action control. *Psychological Research*, *72*, 203–210.
Hauf, P., Elsner, B., & Aschersleben, G. (2004). The role of action effects in infants' action control. *Psychological Research*, *68*, 115–125.
Hayne, H. (2004). Infant memory development: Implications for childhood amnesia. *Developmental Review*, *24*, 33–73.
Hayne, H., Boniface, J., & Barr, R. (2000). The development of declarative memory in human infants: Age-related changes in deferred imitation. *Behavioral Neuroscience*, *114*, 77–83.
Hayne, H., & Findlay, N. (1995). Contextual control of memory retrieval in infancy: Evidence for associative priming. *Infant Behavior and Development*, *18*, 195–207.
Hayne, H., Herbert, J., & Simcock, G. (2003). Imitation from television by 24- and 30-month-olds. *Developmental Science*, *6*, 254–261.
Hayne, H., MacDonald, S., & Barr, R. (1997). Developmental changes in the specificity of memory over the second year of life. *Infant Behavior and Development*, *20*, 233–245.
Hayne, H., Rovee-Collier, C., & Perris, E. E. (1987). Categorization and memory retrieval in 3-month-olds. *Child Development*, *58*, 750–767.
Herbert, J., & Hayne, H. (2000). Memory retrieval by 18–30-month-olds: Age-related changes in representational flexibility. *Developmental Psychology, 36*, 473–484.

Hofer, T., Hauf, P., & Aschersleben, G. (2007). Infants' perception of goal-directed actions on video. *British Journal of Developmental Psychology*, *25*, 485–498.

Hudson, J. A., & Sheffield, E. G. (1999). The role of reminders in young children's memory development. In C. S. Tamis-LeMonda, & L. Balter (Eds.), *Child psychology*: *A handbook of contemporary issues* (pp. 193–214). New York, NY: Psychology Press.

Huston, A. C., & Wright, J. C. (1983). Children's processing of television: The informative functions of formal features. In J. Bryant, & D. R. Anderson (Eds.), *Children's understanding of television*: *Research on attention and comprehension* (pp. 35–68). New York: Academic Press, Inc.

Klein, A., Hauf, P., & Aschersleben, G. (2006). A comparison of televised model and live model in infant action control: How crucial are action effects? *Infant Behavior and Development*, *29*, 535–544.

Krcmar, M., Grela, B., & Lin, K. (2007). Can toddlers learn vocabulary from television? An experimental approach. *Media Psychology*, *10*, 41–63.

Kuhl, P. K., Tsao, F., & Liu, H. (2003). Foreign language experience in infancy: Effects of short term exposure and interaction on phonetic learning. *Proceedings of the National Academy of Sciences*, *100*, 9096–9101.

Linebarger, D. L., & Vaala, S. E. (2008). Babies and TV: Relations between viewing and language development. Paper presented at the *2nd International Conference on Early Childhood Education*, Arnhem, Netherlands.

Linebarger, D. L., & Vaala, S. (2009). Infants and toddlers, screen media, and language development: A review. *Developmental Review*.

Linebarger, D. L., & Walker, D. (2005). Infants' and toddlers' television viewing and language outcomes. *American Behavioral Scientist*, *48*, 624–645.

McCall, R. B., Parke, R. D., & Kavanaugh, R. D. (1977). Imitation of live and televised models by children one to three years of age. *Monographs of the Society for Research in Child Development*, *42*(Serial no. 173).

Meltzoff, A. N. (1988). Imitation of televised models by infants. *Child Development*, *59*, 1221–1229.

Meltzoff, A. N. (1993). Molyneux's babies: Cross-modal perception, imitation and the mind of the preverbal infant. In B. Brewer, N. Eilan, & R. A. McCarthy (Eds.), *Spatial representation*: *Problems in philosophy and psychology* (pp. 219–235). Malden, MA: Blackwell.

Mumme, D. L., & Fernald, A. (2003). The infant as onlooker: learning from emotional reactions observed in a television scenario. *Child Development*, *74*, 221–237.

Nakao, K., & Treas, J. (1992). *The 1989 socioeconomic index of occupations: Construction from the 1989 occupational prestige scores (No. 74)*. Chicago, IL: NORC.

Nielsen, M., Simcock, G., & Jenkins, L. (2008). The effects of social engagement on 24-month-olds' imitation from live and televised models. *Developmental Science*, *11*, 722–731.

O'Doherty, K. D. (2009). *Third party social interaction and word learning from video*. Unpublished master's thesis, Vanderbilt University.

Prinz, W. (1997). Perception and action planning. *European Journal of Cognitive Psychology*, *9*, 129–154.

Rice, M. L., Huston, A. C., Truglio, R., & Wright, J. (1990). Words from 'Sesame Street': Learning vocabulary while viewing. *Developmental Psychology*, *26*, 421–428.

Rice, M. L., Huston, A. C., & Wright, J. C. (1982). The forms of television: Effects on children's attention, comprehension, and social behavior. In L. B. D. Pearl, & J. Lazar (Eds.), *Television and behavior*: *Ten years of scientific progress and implications for the eighties. Volume II*: *technical reviews* (DHHS Publication No. (ADM) 82-1196). Washington, DC: U.S. Government Printing Office.

Rideout, V., & Hamel, E. (2006). *The media family*: *Electronic media in the lives of infants, toddlers, preschoolers, and their parents*. Menlo Park, CA: Kaiser Family Foundation.

Rideout, V. J., Vandewater, E. A., & Wartella, E. A. (2003). *Zero to six*: *Electronic media in the lives of infants, toddlers and preschoolers.* Menlo Park, CA: Kaiser Family Foundation.

Saffran, J. R., Loman, M. M., & Robertson, R. R. W. (2000). Infant memory for musical experiences. *Cognition*, *77*, B15–B23.

Schmitt, K. L., & Anderson, D. R. (2002). Television and reality: Toddlers' use of visual information from video to guide behavior. *Media Psychology*, *4*, 51–76.

Sell, M. A., Ray, G. E., & Lovelace, L. (1995). Preschool children's comprehension of a Sesame Street video tape: The effects of repeated viewing and previewing instructions. *Educational Technology Research and Development*, *43*, 49–60.

DOI: 10.1002/icd

Sheffield, E. G., & Hudson, J. A. (2006). You must remember this: Effects of video and photograph reminders on 18-month-olds' event memory. *Journal of Cognition and Development*, *7*, 73–93.

Simcock, G., & DeLoache, J. S. (2006). The effects of iconicity on re-enactment from picture books by 18- to 30-month-old children. *Developmental Psychology*, *42*, 1352–1357.

Strouse, G. A., & Troseth, G. L. (2008). 'Don't try this at home': Toddlers' imitation of new skills from people on video. *Journal of Experimental Child Psychology*, *101*, 262–280.

Suddendorf, T. (2003). Early representational insight: twenty-four-month-olds can use a photo to find an object in the world. *Child Development*, *74*, 896–904.

Suddendorf, T., Simcock, G., & Nielsen, M. (2007). Visual self-recognition in mirrors and live videos: Evidence for a developmental asynchrony. *Cognitive Development*, *22*, 185–196.

Stein, A., & Friederich, L. (1975). Impact of television on children and youth. In E. M. Hetherington (Ed.), *Review of child development research* (Vol. 5, pp. 183–256). Chicago: University of Chicago Press.

Trainor, L. J. (1996). Infant preferences for infant-directed versus noninfant-directed playsongs and lullabies. *Infant Behavior and Development*, *19*, 83–96.

Trehub, S. E. (2003). The developmental origins of musicality. *Nature Neuroscience*, *6*, 669–673.

Trehub, S. E., Bull, D., & Thorpe, L. A. (1984). Infants' perception of melodies: The role of melodic contour. *Child Development*, *55*, 821–830.

Troseth, G. (2003). TV guide: Two-year-old children learn to use video as a source of information. *Developmental Psychology*, *39*, 140–150.

Troseth, G. L., & DeLoache, J. S. (1998). The medium can obscure the message: Young children's understanding of video. *Child Development*, *69*, 950–965.

Troseth, G. L., Saylor, M. M., & Archer, A. H. (2006). Young children's use of video as a source of socially relevant information. *Child Development*, *77*, 786–799.

Vandewater, E., Park, S. E., Lee, S. J., & Barr, R. (in press). Transfer of learning from video to books during toddlerhood: Matching words across context change. *Journal of Children and Media*.

Wright, J. C., Huston, A. C., Murphy, K. C., St Peters, M., Pinon, M., Scantlin, R., & Kotler, J. (2001). The relations of early television viewing to school readiness and vocabulary of children from low-income families: The early window project. *Child Development*, *72*, 1347–1366.

Zack, E., Barr, R., Gerhardstein, P., Dickerson, K., & Meltzoff, A. N. (2009). Infant imitation from television using novel touch-screen technology. *British Journal of Developmental Psychology*, *27*, 13–26.

Zentner, M. R., & Kagen, J. (1998). Perception of consonance and disconsonance in music. *Infant Behavior and Development*, *21*, 483–492.

Zimmerman, F. J., Christakis, D. A., & Meltzoff, A. N. (2007a). Television and DVD/video viewing in children younger than 2 years. *Archives of Pediatrics and Adolescent Medicine*, *161*, 437–479.

Zimmerman, F. J., Christakis, D. A., & Meltzoff, A. N. (2007b). Associations between media viewing and language development in children under 2 years. *Journal of Pediatrics*, *151*, 364–368.