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Infant imitation from television using novel touch screen technology

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Infants learn less from a televised demonstration than from a live demonstration, the *video deficit effect*. The present study employs a novel approach, using touch screen technology to examine 15-month olds' transfer of learning. Infants were randomly assigned either to within-dimension (2D/2D or 3D/3D) or cross-dimension (3D/2D or 2D/3D) conditions. For the within-dimension conditions, an experimenter demonstrated an action by pushing a virtual button on a 2D screen or a real button on a 3D object. Infants were then given the opportunity to imitate using the same screen or object. For the 3D/2D condition, an experimenter demonstrated the action on the 3D object, and infants were given the opportunity to reproduce the action on a 2D touch screen (and vice versa for the 2D/3D condition). Infants produced significantly fewer target actions in the cross-dimension conditions than in the within-dimension conditions. These findings have important implications for infants' understanding and learning from 2D images and for their using 2D media as the basis of actions in the real world.

Early screen media exposure has come to the forefront of public health debate as parents increasingly use computers, television, and interactive books and games as teaching tools with infants in the first year of life (Rideout & Hamel, 2006; Zimmerman, Christakis, & Meltzoff, 2007). Over the past 15 years, the media landscape for infants has changed dramatically. During the 1990's, television programs such as *Teletubbies* and videos/DVDs such as *Baby Einstein* started to be produced specifically for infants. In a typical infant-directed video, images of everyday objects, toys, and puppets are shown set to music without narration or a storyline. Sales estimates of infant media products were $100 million dollars annually in the US in 2004 (Garrison & Christakis, 2005) and some estimates put them as high as $200 million today. Most recently *V.Smile* and

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Leapfrog have started producing educational videogames and interactive books that use touchpads for children 3 years and younger.

In some cases, infant videos/DVDs and TV programs are marketed in a way that leads parents to believe their babies will engage in important learning from them (Garrison & Christakis, 2005). Parents believe that there are beneficial effects of very early exposure to television and computers (Calvert, Rideout, Woolard, Barr, & Strouse, 2005). For example, in a 2006 survey of 1,000 US families with children between 2 and 24 months old, the leading justification parents gave for fostering infant video/DVD viewing was that such media 'teach him/her something or are good for his/her brain' (Zimmerman *et al.*, 2007). Nonetheless, whether and *how* infants and toddlers learn from 2D sources and transfer information so that it can be used to control action in the real world has not received sufficient empirical attention (see Anderson & Pempek, 2005). This study is the first that we know of to experimentally examine transfer of learning from an interactive touch screen interface to real world objects during infancy.

Video-deficit effect

Empirical research conducted using a number of different experimental paradigms has demonstrated that infants, toddlers, and preschool children learn less from television and 2D still images than from live face-to-face interactions (Anderson & Pempek, 2005; Barr & Hayne, 1999; Barr, Muentener, & Garcia, 2007a; Barr, Muentener, Garcia, Fujimoto, & Chavez, 2007b; DeLoache & Burns, 1994; Deocampo & Hudson, 2005; Grela, Krcmar, & Lin, 2004; Hayne, Herbert, & Simcock, 2003; Hudson & Sheffield, 1999; Kuhl, Tsao, & Liu, 2003; McCall, Parke, & Kavanaugh, 1977; Mumme & Fernald, 2003; Schmitt & Anderson, 2002; Sell, Ray, & Lovelace, 1995; Sheffield & Hudson, 2006; Simcock & DeLoache, 2006; 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 (Anderson & Pempek, 2005) compared to their impressive transfer of learning from a live demonstration to a different situation (Anderson & Pempek, 2005; Klein & Meltzoff, 1999). In the case of imitation studies, beginning around 6–14 months of age, infants can imitate limited actions demonstrated by videotaped models (Barr *et al.*, 2007a; Meltzoff, 1988a). The video deficit for imitating from 2D displays has been reported to peak around 15 months and persist until 30 months (Barr & Hayne, 1999; Barr *et al.*, 2007a,b; Hayne *et al.*, 2003; McCall *et al.*, 1977).

In most previous studies examining imitation from television, children were required to observe a demonstration on a 2D source and then reproduce the target actions on a 3D object. That is, the infants encode a representation of the action from a 2D input and then successfully retrieve a memory of the action in the presence of a 3D object. Such a design does not allow determination of whether the reported video deficit effect arises from: (a) perceptual impoverishment of the 2D stimulus; (b) poor understanding of the 2D array (e.g. due to an inability to appreciate the dual nature of symbols); (c) poor representational flexibility due to the cognitive load involved in transferring information from a 2D demonstration to a 3D object; or (d) from a combination of these factors.

Perceptual encoding impoverishment

Mapping a memory encoded from a 2D image on to a 3D object presented at a later time, and used for the basis of action, relies on a representation of the object that can enable translation between dimensions. The need for a translation between images and objects presents significant challenges. Two-dimensional images may be difficult for toddlers to understand for a number of perceptual reasons: In most laboratory tests, they are smaller in size than the real objects, the resolution of the image is degraded relative to real objects, and many aspects of the object (depth cues from self-induced motion, shadow, and gradients, for example) are at best absent, and at worst substantially different, across the 3D–2D change. Even colour values are likely to change to some degree when a TV image replaces a 3D object.

This impoverished presentation may have substantial implications for visual processing. Two recent studies suggest that 2D information is processed differently than 3D information during infancy. First, researchers using event-related potentials (ERPs) have demonstrated that 18-month-olds process 2D images more slowly than 3D objects, recognizing a familiar 3D object very early in the attention process (shown by the early sensory exogenous N2 component) and recognizing a 2D digital photo of the familiar object significantly later (during the middle latency Nc component) (Carver, Meltzoff, & Dawson, 2006). Second, researchers using near-infrared spectroscopy (NIRS) have demonstrated that 6-month-olds actively process live demonstrations of action in the sensorimotor cortex more than when the same information is presented on television (Shimada & Hiraki, 2006). It is possible that this difference is preserved throughout life (see Bennett & Vuong, 2006; Wang & Kameda, 2005).

Poor understanding of 2D symbols and dual representations

DeLoache and colleagues (DeLoache, 1995; DeLoache, Kolstad, & Anderson, 1991; Pierroutsakos & DeLoache, 2003; Troseth, Pierroutsakos, & DeLoache, 2004) have proposed a *dual representation hypothesis* to account for the video deficit effect. They argue that children's difficulty relating 2D depictions (moving or stationary) to the real world is due to young children's immature understanding of symbolic artefacts such as pictures and television. Early in development, toddlers do not understand the dual nature of symbols. That is, toddlers do not comprehend that a symbol is both an object in itself (e.g. a television set) as well as a representation of another entity (e.g. the depiction on the monitor).

One important developmental step in learning from television and computers is appreciating both the similarities and the differences between 2D and 3D stimuli and being able to act accordingly (Flavell, Flavell, Green, & Korfmacher, 1990; Rose, 1977; Troseth *et al.*, 2004). That this ability develops is buttressed by published reports that in the first year of life, infants sometimes treat objects on television as if they have 3D properties. They have been observed to manually explore 2D images and try to grasp them in ways that are reminiscent of how they interact with 3D objects (Flavell *et al.*, 1990; Lemish, 1987; Pierroutsakos & DeLoache, 2003; Pierroutsakos & Troseth, 2003). According to this account, it is during the 2nd year of life that infants more sharply differentiate 2D images and 3D objects and learning from television decreases (the video deficit effect). This decrease in learning suggests that the developmental course of this ability does not result from a simple linear increase in perceptual capacity.

DeLoache (1991) argues that not until toddlers have sufficient experience with a range of symbols do they begin to understand their representational power and thus begin to relate them to the real world in an adult-like way. Two-year-olds fail to apply information presented on television to real world situations (Troseth & DeLoache, 1998; Troseth, Saylor, & Archer, 2006). Thus, the informational value of actions presented in 2D (on video) is substantially diminished because children do not recognize the functional significance of the objects and actions they view on the screen. According to this view, it is not until almost the third year of life that children come to understand that video can provide meaningful information to guide actions in the real world, and the video deficit effect disappears.

Poor representational flexibility

Although the perceptual impoverishment and dual representation accounts differ in their explanations of the video deficit, they both agree that the very nature of the media makes it difficult for toddlers to understand and relate to corresponding real-world objects. The representational flexibility account emphasizes a different type of difficulty presented by the need to equate between television (and other 2D media) and 3D objects. According to this account, the challenge is that the toddler must cognitively match a 2D symbol present at encoding to the corresponding 3D referent present at testing. Memory theorists generally assume that a memory is a hypothetical collection of attributes that represent what the subject noticed at the time of original encoding (Estes, 1973, 1976; Roediger, 2000; Spear, 1978; Tulving, 1983; Underwood, 1969). The encoding specificity hypothesis states that a memory will be retrieved only if an individual encounters a cue with attributes that match those represented in the memory at the time of original encoding (Tulving, 1983). The ability to retrieve memories despite changes in proximal or distal cues to allow learning to be generalized to novel situations has been referred to as 'representational flexibility' (Eichenbaum, 1997).

Hayne (2004) argues that there are marked developmental changes in representational flexibility in infancy. That is, early in development, successful memory performance is dependent on the perception of a close match between the cues at the time of encoding and the cues at retrieval; even minor mismatch at testing can disrupt performance. Of course, this process depends upon a match or mismatch being detected. During the first year of life infants may be matching the surface features (and not basing their actions on the discrepancy between 2D and 3D objects – see the dual representation hypothesis above for a similar argument). Thus the onset of the video deficit occurs during the second year of life when a mismatch is detected. However, subsequent to the onset of this effect, memory performance becomes more flexible with age and older participants show an increased ability to tolerate differences between conditions at encoding and retrieval and can use novel cues to retrieve a target memory. This has been supported empirically with infants showing excellent generalization using operant conditioning procedures (Hartshorn *et al.*, 1998; Hayne & Findlay, 1995; Hayne, Rovee-Collier, & Perris, 1987) and with toddlers using the imitation paradigm (Barnat, Klein, & Meltzoff, 1996; Hanna & Meltzoff, 1993; Hayne, Boniface, & Barr, 2000; Hayne, MacDonald, & Barr, 1997; Hayne *et al.*, 2003; Herbert & Hayne, 2000; Klein & Meltzoff, 1999). Ultimately success on the transfer task would depend on the operation of a flexible capacity to recognize and act on the stimulus regardless of its dimension at the time of encoding.

The imitation paradigm

The imitation paradigm provides a powerful way of investigating the video deficit effect. Based on Piaget's (1962) theoretical conceptualization, Meltzoff (1988b,c, 1995) introduced a deferred imitation paradigm that can be used in the laboratory with infants. In this paradigm, infants observe an experimenter demonstrating a novel action, usually several times in succession. Then, infants are given the opportunity to reproduce the action with the objects either immediately or after a specified delay. Their performance is compared to that of an age-matched control group who never saw the demonstration – the performance of these infants is used to determine the rate of spontaneous production of the target actions. There are key aspects of Meltzoff's deferred imitation paradigm that make it a useful tool for studying high-level cognition in a preverbal population: (a) the participant is prevented from interacting with the objects prior to the test, which precludes motor learning; (b) the duration of the response phase is controlled; (c) imitative performance is compared to a no-model control group, which reduces the likelihood that the participant is guessing the target actions based on the appearance of the objects; and (d) the responses that count as imitative are rigorously defined and scored from videotape records by scorers who are blind to experimental condition.

Imitation from television

Meltzoff (1988a) adapted the imitation procedure to televised stimuli. He exposed infants to a televised model demonstrating a novel target action. He found that infants as young as 14 months of age reproduced a one-step action viewed on television above rates produced by age-matched controls who never viewed the target action. The study documented both immediate and deferred imitation (spanning a 24-hour delay). Successful deferred imitation from a videotaped model requires formation of both an object and an action representation that can be retained over a delay. At the time of the test, infants must match perceptual attributes of the 3D test object that is presented to the child to stored attributes of the memory representation of the original 2D video display. Meltzoff's study was an 'existence proof' that infants could imitate from television; the video deficit effect is based on the fact that infants are not as *proficient* at imitating from television as they are when imitating live, 3D models.

The present study

Prior imitation studies have used traditional television to present the 2D stimuli and then assessed infants' performance with a 3D test object. It is possible that any decrement in performance as compared to live demonstrations is simply due to encoding from a degraded/impoverished 2D stimulus. One innovation of the current study is the use of touch screen technology that permits tests from 2D to 2D and from 3D to 2D (as well as testing from 2D to 3D as before). Combining the touch screen methodology with the imitation approach will contribute to the nascent literature examining learning and educational applications from 2D media during infancy, adding to our understanding of comprehension of media in very young and vulnerable populations (e.g. Barr *et al.*, 2007a,b; Troseth *et al.*, 2006; Zimmerman *et al.*, 2007). Based on Hayne's representational flexibility hypothesis, transferring information from 2D stimuli to 3D objects (and vice versa) would be more challenging than relating objects within the same dimension (i.e. 2D to 2D or 3D to 3D) because there are fewer retrieval cues at the time of the test that specifically match the original encoding conditions.

The present experiment examines imitation from 2D and 3D surfaces and transfer across dimensions. We sought to establish the feasibility of the combined imitation-touch screen methodology. We had the following specific aims: (a) to obtain the baseline rate of button pushing for the 2D touch screen and 3D objects; (b) to establish whether infants would imitate the target actions on the 2D touch screen and the 3D object; and (c) to test whether infants would imitate across dimension.

Method

Participants

Seventy-two 15- to 16-month-old (26 male, 46 female) full-term healthy infants and their parents were recruited through commercially available records, child care centers, and by word of mouth in the DC metro (65.3% of data) and Binghamton metro (34.7% data) areas. Infants ranged in age from 431 days to 521 days ($M = 476.2$, $SD = 19.0$). Participants were African-American ($N = 1$), Asian ($N = 1$), Caucasian ($N = 66$), mixed descent ($N = 3$), and unreported ($N = 1$). The Caucasian sample included one Latino participant. The majority of infants were from middle- to upper-class, highly educated families. Their parents' mean educational attainment was 17.0 years ($SD = 1.45$) based on 93.6% of the sample, and their mean rank of socio-economic status (Nakao & Treas, 1992) was 72.2 ($SD = 19.2$) based on 84.7% of the sample. Infants were randomly assigned to one of six experimental groups ($N = 12$/group; see Table 1): *3D demo/3D test*; *2D demo/2D test*; *3D demo/2D test*; *2D demo/3D test*; *3D baseline control*; and *2D baseline control*. Additional infants were excluded from the final sample due to experimenter error or interference ($N = 3$), parental interference ($N = 1$), or failure to touch the stimuli during the test phase or failure to sit through demonstration ($N = 3$).

Table 1. Experimental demonstration and test groups

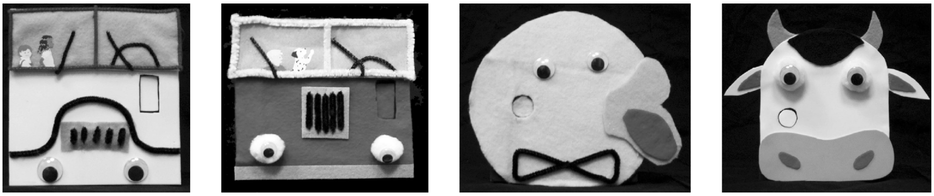
Group	Demo	Experimenter action	Test
Within-dimension			
3D demo/3D test	Real object	Press button on 3D stimulus	Real object
2D demo/2D test	Touch screen	Press virtual button on 2D stimulus	Touch screen
Cross-dimension			
3D demo/2D test	Real object	Press button on 3D stimulus	Touch screen
2D demo/3D test	Touch screen	Press virtual button on 2D stimulus	Real object
Baseline			
3D baseline			Real object
2D baseline			Touch screen

Apparatus

We adapted button boxes that had been developed by Meltzoff (1988a) for use in previous imitation studies. None of the completed stimulus objects was commercially available.

3D stimuli

Four novel objects were created from a black button box (16.5 wide × 15 tall × 5.5 cm deep) decorated with felt, art foam, pipe cleaners, stickers, cotton balls, and googly eyes to create a school bus, a fire truck, a cow, and a duck (see Figure 1). The two vehicles (bus and fire truck) have a slightly recessed rectangle-shaped button (2.2 × 3 cm) on the right surface in the middle of the box (16.5 wide × 15 tall × 5.5 cm deep). The two animals (duck and cow) have a slightly recessed circular button (2.2 × 2.2 cm in diameter) on the left surface in the middle of the box (16.5 wide × 15 tall × 5.5 cm deep). Pressing the button activates a switch which produces a different sound for each object: a horn honking (bus); a siren (fire truck); duck quacking; or cow mooing.



(A) Bus button box (B) Fire truck button box (C) Duck button box (D) Cow button box

Figure 1. The button boxes (16.5 wide × 15 tall × 5.5 cm) have a recessed button that make the sound of a: (A) horn honking, (B) siren, (C) duck quacking, or (D) cow mooing when pressed.

2D stimuli and touch screen

Digital photos were taken of each of the four previously described 3D objects and displayed on a 17 in. LCD touch screen (see Figure 2). The touch screen was connected to a laptop and programmed with the images of the 3D objects using software used in various touch screen tests of infants (e.g. Gerhardstein & Rovee-Collier, 2002). The button areas were programmed such that pressing the 'virtual button' produced the same sound as pressing the actual button on the 3D object. The images were equated in size to the 3D object at approximately the same viewing distance.

Experimental set-up

A lap table (61 wide × 32 tall × 37.5 cm deep) was placed on the floor and used as the testing surface for all conditions. The 3D object or 2D touch screen was placed on the lap table, as shown in Figure 2. Children sat on a child size step stool or their caregiver's lap. Every child saw one vehicle and one animal stimulus (e.g. truck/cow); stimulus and presentation order were counterbalanced within and between groups. Stimuli were covered and kept out of the infant's sight when not in use.

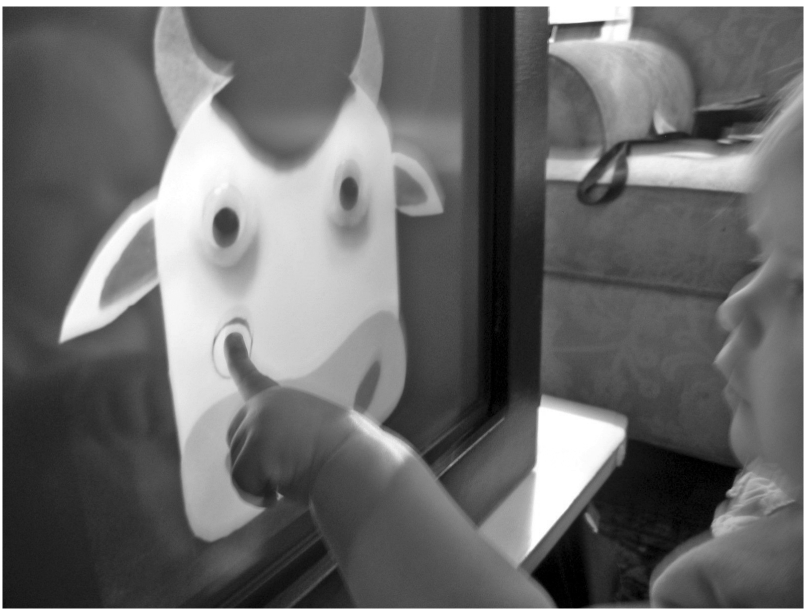


Figure 2. Sample photograph of imitation of the target action on the 2D touch screen image.

Procedure

Infants were primarily visited in their homes; however a small subset of participants ($N = 6$) were tested in a child care center. All participants were tested in a single session. An experimenter described the study to and obtained informed consent from the caregiver. Before the start of the session, caregivers were instructed not to name the object or the sound it makes, or to point out anything on the stimulus, including the button. Caregivers were permitted to respond to what their infant was interested in (e.g. you're touching the eyes), to say neutral phrases (e.g. look at that) or to offer encouragement if the infant responded correctly (e.g. good job) during the test phase. A second experimenter videotaped the session from a side angle, such that both the infant and the object/touch screen were visible. All phases of the experiment were videotaped for later analysis.

Half of the infants were administered a within-dimension test (3D demo/3D test, 2D demo/2D test) and half were administered a cross-dimension test (2D demo/3D test, 3D demo/2D test). The *2D* and *3D baseline control* groups were used to assess the spontaneous production of the target actions in the absence of the demonstration. Infants in these baseline control groups did not participate in the demonstration phase. Rather, they were shown the test stimuli for the first time during the test phase.

Demonstration phase

The session began with the infant seated approximately three feet away from the lap table. An experimenter knelt down next to the table on the side of the stimulus opposite the button/virtual button (e.g. the cow button is on the left side of the object/image so the experimenter knelt on the right side of the table). The experimenter demonstrated the target action six times in succession for the first stimulus by extending the index finger and reaching across the front of the stimulus (3D object or 2D image) to push the button/virtual button. The target actions were not verbally described, but to maintain the infants' attention on the test stimuli, the experimenter used phrases such as, 'Isn't this fun?' speaking in a manner characteristic of 'parentese.' Following the six demonstrations with the first stimulus, the stimulus was removed and the experimenter moved to the opposite side of the table and repeated the above procedure for the second stimulus. The demonstration period was fixed at approximately 30 seconds per stimulus ($M = 32.1$ seconds, $SD = 4.0$ for the 3D objects and $M = 33.8$ seconds, $SD = 7.0$ for the 2D touch screen images). Small variations in the demonstration times were due to occasional interruptions in the household, such as a phone ringing, technical problems on the touch screen, or infant fussiness. At the end of the demonstration phase, caregivers moved their infants forward so that they were seated at the table. There was a delay of less than 20 seconds between the demonstration and test phase, regardless of condition.

Test phase

The test phase was the same for all infants. During the test phase, the infant was seated at the lap table facing the toy/touch screen image. Infants were given 30 seconds from time of first touch of the toy or screen to imitate the target action on each stimulus. Stimuli were presented in the same order as during the demonstration. Infants in the experimental groups were tested with the same animal and vehicle they viewed during the demonstration.

Survey data on television exposure

To estimate the amount of daily exposure to television by infants in our total sample, parents were asked how many hours per day their televisions were typically in use. This information was collected from 69.4% of parents. Parents reported that the television was on for an average of 2.6 hours per day ($SD = 1.6$ hours). This is consistent with recent nationally representative sample data (e.g. Rideout & Hamel, 2006).

Coding and reliability

A primary coder scored whether infants imitated the target action (pressing the button) during the test session from videotape (see Figure 2). For each test trial, an imitation score of '0' was given if the infant did not press the button within 30 seconds from time of first touch or a '1' if the infant did press the button within 30 seconds. Participants' responses were tallied across stimuli and averaged to yield a single score (range of 0–1). A secondary coder scored 75% of the sessions; inter-observer reliability was 100%.

Results

Preliminary analyses revealed that sex of the infant, or laboratory (Georgetown or Binghamton) did not produce any significant main effects or enter into any interactions.

Results show evidence of imitation from both the 2D touch screen image and 3D object. A one-way ANOVA across condition (baseline 2D, baseline 3D, 3D/2D, 2D/3D, 3D/3D, 2D/2D) revealed a main effect of condition, $F(5, 66) = 25.29$, $p < .001$, (partial $\eta^2 = .66$). As shown in Figure 3, *post hoc* Student–Newman-Keuls tests revealed that the within-dimension groups (2D/2D and 3D/3D) performed significantly better than their baseline controls and the cross-dimension groups. Both 2D/3D and 3D/2D groups significantly exceeded baseline.

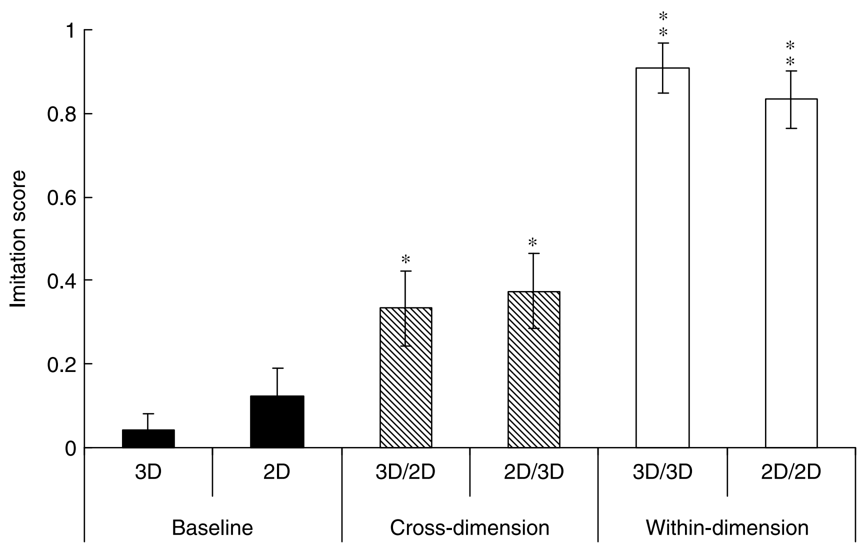


Figure 3. The mean imitation score of infants as a function of experimental condition: Baseline (2D or 3D), cross-dimension (2D/3D or 3D/2D) and within-dimension (3D/3D or 2D/2D). An asterisk indicates that the group performed significantly above baseline. Two asterisks indicate that the group performed above baseline and the other experimental conditions.

Discussion

The present work used a touch screen procedure in order to localize the source of the video deficit effect. The three aims of the study were achieved. We established the baseline for the 2D touch screen test and 3D object test. Both were low. We established that infants can imitate the target actions on the 2D touch screen and the 3D object. Both groups performed significantly above baseline and there were no differences between the within-dimension (2D/2D and 3D/3D) conditions. We also found that infants can imitate across dimensions. Both the 2D/3D and 3D/2D groups performed above baseline, with no differences between the cross-dimension groups based on the direction of transfer. Notably both cross-dimension groups performed significantly worse than the within-dimension groups. That is, the cross-dimension groups exhibited the typical video deficit effect, even though the 2D medium was a touch screen, and this occurred whether the infants first observed the action on the 2D display and had to generalize to the 3D object or the reverse. Thus, the rate-limiting step in learning and acting via interactive media was the transfer of information between 2D and 3D.

From a theoretical point of view, use of 2D stimuli such as video and computers provide a good model for extending our knowledge about the nature and growth of representation during infancy. In particular, we examined the effects of the 2D stimuli on encoding and retrieval and found that encoding and retrieval from a 2D image was comparable to encoding and retrieval from a 3D object. That is, the infants did just as well in imitating in 2D/2D as they did in 3D/3D. They do not seem to have problems with using the 2D image itself. This is not the bottleneck.

This is a surprising finding for both the perceptual impoverishment and for dual representation accounts. From a perceptual impoverishment perspective, encoding and retrieval from a 2D presentation should have been limited. However, the successful performance of infants in the 2D/2D group demonstrates that the image was not so impoverished so as to block imitation. Furthermore, the 3D/2D and 2D/3D cross-dimension groups did not differ from one another suggesting that an impoverished 2D stimulus does not account for the video deficit effect. From a dual representation perspective, learning on a symbol itself would be expected to be diminished at this age because toddlers of this age are hypothesized to focus on the fundamental *differences* between 2D and 3D properties. Infants would be expected to not understand the significance of the object and action they viewed during the demonstration on the 2D touch screen, and therefore would fail to act on a televised display during test. In contrast, we found that infants successfully imitated the action on the touch screen when the demonstration was also on the screen (2D/2D condition). It is possible, however, that the live adult demonstration of the function of the touch screen allowed infants to imitate from a 2D symbol when they otherwise would not interact with a 2D image.

These findings are consistent with the developmental representational flexibility account (e.g. Hayne, 2004). Following from this viewpoint, successful memory performance is dependent on the precision of the match between the cues present at the time of encoding and the cues available at retrieval; and/or a lack of cues at the time of retrieval may negatively impact performance. A lack of such cues may have compromised infants' ability to retrieve the representation of the initial display in the cross-dimension test (Hayne, 2004). Because the 2D symbol shares fewer attributes with the 3D test objects, transferring of information across dimensions is more challenging from these media.

The present findings show that it is cognitively challenging to transfer information across dimensions, suggesting that during infancy the transfer of learning from computers or television to the real world may not be as easy as previously imagined. Further studies are needed to examine whether presenting the 2D images and 3D objects simultaneously enhances transfer ability, whether adding additional perceptual or verbal retrieval cues will decrease cognitive load and enhance transfer across dimensions, and whether adding a delay between demonstration and test will increase cognitive load and decrease overall performance. We are currently investigating these possibilities. Locating where the representation breaks down will provide us with important information regarding the emerging representational system and how it interacts with the perceptual and linguistic development and children's use of interactive media.

The development of an imitation task that utilizes touch screen technology provides an important avenue for future research. It is critical to establish procedures that do not involve highly familiar products to be able to systematically dissect the learning process. Commercial products are difficult to study empirically because of different rates of exposure to such products. Development of viable and experimentally controlled analogues will allow us to make inferences about how infants learn in the context of television, computers, and other interactive new media marketed for children. From a practical point of view, these findings provide important information for parents, educators, and industry. There are a plethora of television programs, computer games, and 'new media' designed for consumption by young children. However, at this point in time there is very little empirically based information available on infants' learning from such media and their use of such information and learning to guide real-world actions. Thus there is a critical gap for people who want to design and use these media as effective teaching tools.

Overall, the present study establishes a new method to examine the video deficit effect and information transfer across dimensions during infancy. Further studies using this methodology will be able to probe infant learning from media and provide important insights into early infant learning among an ever-expanding array of media choices for very young children.

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