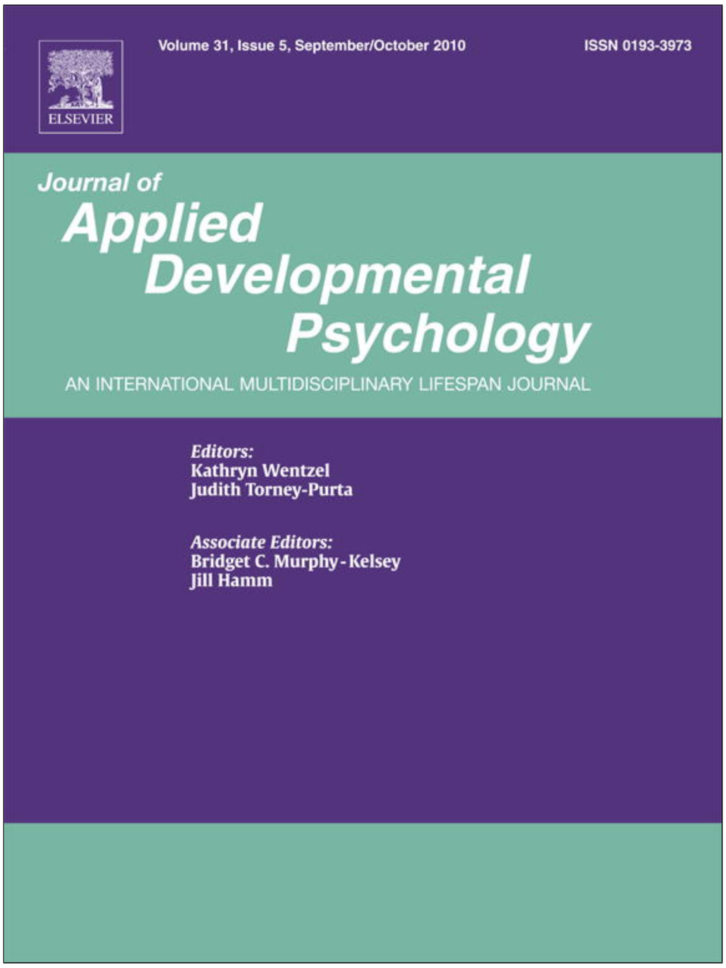
Volume 31, Issue 5, September/October 2010
ISSN 0193-3973
ELSEVIER
Journal of
Applied
Developmental
Psychology
AN INTERNATIONAL MULTIDISCIPLINARY LIFESPAN JOURNAL
Editors:
Kathryn Wentzel
Judith Torney-Purta
Associate Editors:
Bridget C. Murphy-Kelsey
Jill Hamm

Journal of Applied Developmental Psychology 31 (2010) 362–369

Contents lists available at ScienceDirect

Journal of Applied Developmental Psychology

Contingent computer interactions for young children's object retrieval success

Alexis R. Lauricella [a], Tiffany A. Pempek [b], Rachel Barr [a], Sandra L. Calvert [a,*]

[a] Children's Digital Media Center, 309 White Gravenor Hall, Georgetown University, 37th & O Streets, NW, Washington, DC 20057, USA
[b] Department of Psychology, One Otterbein College, Westerville, OH 43081, USA

ARTICLE INFO

Article history:
Received 7 May 2009
Received in revised form 30 April 2010
Accepted 5 June 2010
Available online 24 July 2010

Keywords:
Computers
Contingency
Television
Object retrieval
Video deficit
Children

ABSTRACT

Seventy-two children, ages 30 and 36 months, participated in a hide-and-seek object retrieval game in one of three conditions: 1) playing an interactive computer game; 2) observing a video; or 3) observing an adult find the hidden characters through a one-way mirror. After exposure, children searched for the three characters in a playroom designed to look just like the room in the game. Children who played the interactive computer game and who observed the live demonstration performed significantly better on the search task than children who observed the video. The results suggest that children's learning from a screen can be improved by contingent, interactive experiences with media. These findings can help producers create online games that facilitate children's skills at linking what they do on a screen to real-life experiences.

Published by Elsevier Inc.

Introduction

Very young children in the United States now live and develop in the presence of a screen. Eighty-eight percent of 24- to 36-month-olds are exposed to screen media, spending an average of 2 h on a typical day with video content, including television programs, DVDs, computer games, and videogames (Rideout & Hamel, 2006). In the first three years of life, 31% of children ages 0–3 years use a computer (Rideout, Vanderwater & Wartella, 2003, beginning on average at age 2.7 years (Calvert, Rideout, Woolard, Barr, & Strouse, 2005). Nine percent of children ages 0–3 play computer games on a typical day (Rideout, Vanderwater, & Wartella, 2003). This increased early media exposure parallels a dramatic recent increase in the production of media, such as DVDs and computer games, designed specifically for infants and toddlers (Garrison & Christakis, 2005; Goodrich, Pempek, & Calvert, 2009).

Although young children use a variety of different screen media, they experience considerable difficulty when translating what they see on a screen to real life. More specifically, until approximately 3 years of age, depending on task complexity, children learn better from a live demonstration than from an equivalent televised demonstration (Barr & Hayne, 1999; Flynn & Whitten, 2008; McCall, Parke, & Kavanaugh, 1977), a problem that researchers labeled the *video deficit* (Anderson & Pempek, 2005).

Not all screen media are alike, however. In particular, a video presentation cannot respond contingently to a child's actions as can live adults and computer games (Rafaeli, 1988). Our purpose here was to examine if playing an interactive computer game improves young children's success at transferring the information presented on a screen to a real-life situation when compared to observing a video or a live presentation.

The video deficit

The object retrieval task is a common paradigm for studying transfer of learning from symbols to real-world environments (e.g., Troseth & DeLoache, 1998). In the object retrieval task, a room is created to look like a typical living room space, which is referred to as the "playroom." In most versions of the object retrieval task, the child either sees where a target object is hidden "live," meaning they watch as the toy is hidden in the playroom through a one-way mirror, or they are shown where the target object is hidden using symbolic depictions such as content presented on a television screen (e.g., Troseth & DeLoache, 1998) or a 3-dimensional scale model (e.g., DeLoache, 1987). After the child views the demonstration, the child reenters the playroom and is asked to find the target object. Successful completion of the task is defined as the number of errorless retrievals in finding the hidden toy (see DeLoache, 1991). When errors are made, they are frequently perseveration errors, in which the child searches for the object in a hiding spot where a previous toy was hidden (Sharon & DeLoache, 2003; Suddendorf, 2003).

Research using these object retrieval tasks demonstrates that 2-year-old children have very little difficulty finding the target objects when they observe an adult hide the object through a one-way mirror (see DeLoache & Burns, 1994 for review). By contrast, very young children struggle to find the target object when they have to interpret a representation of the room to find the object. For example, when young children watched where a toy was hidden on a television

* Corresponding author. Tel.: +1 202 687 4042; fax: +1 202 687 6050.
E-mail addresses: alexislauricella@gmail.com (A.R. Lauricella), rfb5@georgetown.edu (R. Barr), calverts@georgetown.edu (S.L. Calvert).

0193-3973/$ – see front matter. Published by Elsevier Inc.
doi:10.1016/j.appdev.2010.06.002

monitor, 2-year-olds had difficulty finding the hidden toy in the playroom (Schmitt & Anderson, 2002; Troseth & DeLoache, 1998).

According to dual representation theory, children's difficulty in relating 2-dimensional (2D) depictions to the real world is a function of young children's immature understanding of symbolic artifacts like pictures in books or on a television screen (DeLoache, 1991). DeLoache (1991) argues that infants and toddlers do not understand the dual nature of symbols. That is, they do not comprehend that a symbol is both an object in itself (e.g., an image on a television screen or a picture book) as well as a representation of another entity (e.g., the depiction that is presented on the monitor or in the book) (Troseth & DeLoache, 1998). Therefore, very young children focus on the physical characteristics of the symbol and fail to appreciate its representational nature. Not until they have sufficient experience with a range of symbols do they begin to understand the representational depictions and transfer that knowledge to the real world (DeLoache, 1991; Simcock & DeLoache, 2006; Troseth, 2003). This failure to transfer information from a screen to real life is the essence of the video deficit.

Children's age and the overall level of difficulty of the task play a role in young children's successful search performance. When search tasks require children to use a video presentation to find only one hidden toy at a time, older children perform better than younger children (Schmitt & Anderson, 2002; Troseth & DeLoache, 1998). In one study, 2.5-year-olds were successful at finding the hidden toy when presented with information on a television monitor, but 2-year-olds were not (Troseth & DeLoache, 1998). In another study, 3-year-olds were equally successful at finding the hidden toy when they watched the demonstration on video or being hidden by an adult through a one-way mirror; by contrast, 2.5- and 2-year-olds performed worse when they watched the demonstration on the video when compared to children who saw the demonstration performed by an adult through the one-way mirror (Schmitt & Anderson, 2002). Furthermore, at 2.5 years, children fail to transfer learning from a 3D model to a real room, but by 3 years of age children are successful at using a model as a representation to find a hidden toy (DeLoache, 1991). Recent evidence using the deferred imitation paradigm demonstrates that when task complexity is increased, thereby increasing the cognitive load in a transfer task, a video deficit persists until at least 36 months (Flynn & Whiten, 2008; Gerhardstein, Dickerson, Zack, & Barr, 2009; McGuigan, Whiten, Flynn, & Horner, 2007).

Social contingency is one way to help young children link 2D information to the real 3D world, thus reducing the dual representation problem. For instance, extended exposure to closed-circuit television in the home where a child can see himself or herself behaving in real time (Troseth, 2003), or having an experimenter interact with a child on closed-circuit television about personally relevant information prior to a task (e.g., saying the name of their pet; Troseth, Saylor, & Archer, 2006) leads to improved performance on object retrieval tasks. Similarly, when an experimenter interacts with young children via closed-circuit television prior to an imitation task, children imitate more of the exact behaviors demonstrated, even when those behaviors are not the most efficient ones for the task; these findings suggest a social underpinning for imitation (Nielsen, Simcock, & Jenkins, 2008). Taken together, the findings suggest that providing young children with the knowledge that events presented on the screen are *contingent* upon their behavior helps them to link their mental representation of televised information with the task they are subsequently asked to perform.

Repetition also decreases the video deficit for infants (Barr, Muentener, Garcia, Chavez, & Fujimoto, 2007) and improves learning for preschool-aged children who believe that they are interacting with the character. For instance, 3-year-old children were exposed either once or 5 times to an episode of *Blue's Clues*, an educational television program designed for preschoolers in which a character appears to interact with the audience by speaking directly to the audience and pausing for a reply (Anderson et al., 2000). Repeated exposure enhanced children's comprehension of the program content (Crawley, Anderson, Wilder, Williams, & Santomero, 1999), as did responding to character requests to participate with the program content (Anderson et al., 2000).

Effects of contingent computer interactions

Interactive media involve contingent, responsive replies to children's actions (Rafaeli, 1988). To date, no study has assessed how the video deficit may differ when very young children are presented with the same material via an interactive computer game as compared to a video (see Kirkorian, Wartella, & Anderson, 2008). By age 4, children learn well when they use interactive media. For instance, in one study (Calvert, Strong, Jacobs, & Conger, 2007), 4-year-old children were exposed to a video story on a computer. Latina girls who interacted with key parts of the program via a computer mouse understood the content better than those who simply observed the program with an adult. The results suggest that interacting with content can lead to improved comprehension over traditional observation of that same material.

In a related study (Calvert, Strong, & Gallagher, 2005), 4-year-old children were exposed to a computer game four times where they observed an adult control a computer mouse to play the game, controlled game play via the mouse themselves, or jointly shared control with the adult by taking turns with the mouse during game play. As exposure to the game increased, children who controlled or shared control of the computer game remained more attentive and involved in the game whereas those who observed the adult play the game lost attention and interest over repeated exposures. These studies point to the important role of contingent interactions for 4-year-old children's attention to, and comprehension of, computer content. Studies have not, however, examined whether interactions with computers can facilitate transfer of learning at ages below age 4, which is our target age group here.

The present study

The purpose of the present study was to examine whether a video deficit found in an object retrieval task can be overcome via contingent experiences with a computer game. To examine this question, 30- and 36-month-old children participated in a live observation condition, an interactive computer condition, or a video observation condition. We selected 30-month-old children as the youngest age group because that is when children typically first use a computer (Calvert et al., 2005), and our upper range was 36 months of age because children still experience the video deficit with complex tasks at this age (McCall et al., 1977). A video deficit was defined as performance that was significantly less than the performance of the live observation condition.

Our hypotheses were as follows:

1) Based on the literature on children's object search task performance (Troseth & DeLoache, 1998) and contingent learning from closed-circuit television (Troseth, 2003; Troseth et al., 2006), we hypothesized that young children would demonstrate a video deficit on an object retrieval task when watching a video of the game when compared to performance after watching a live demonstration through a one-way mirror; however, based on the literature on children's improved learning from a computer screen over an observational video experience (Calvert et al., 2007), we did not expect a video deficit when children interacted with the material contingently through a computer game when compared to the live condition;
2) Based on the literature on toddlers' contingent learning from closed-circuit television (Troseth, 2003; Troseth et al., 2006) and on 4-year-old children's superior attention to (Calvert et al., 2005) and learning from (Calvert et al., 2007) interactive over observational media, we hypothesized that the contingency provided by pressing a computer key to make an action occur in a computer game would improve

performance on the object retrieval task more than simply watching a video of that same game; and

3) Based on the literature that older children perform better than younger children on search tasks following a live or televised display (Schmitt & Anderson, 2002; Troseth & DeLoache, 1998), we hypothesized that 36-month-old children would perform better after exposure than would 30-month-old children in the live, video, and the computer conditions.

Method

Participants

Seventy-two 30- ($M = 30.48$, $SD = 0.67$) and 36-month-old ($M = 36.11$, $SD = 1.11$) children (36 male), equally divided by age, were randomly assigned to one of three conditions: an interactive computer condition, a video observation condition, or a live observation condition. Five other children were dropped from the sample due to technical problems with the camera or the room setup ($n = 2$), refusal to participate ($n = 2$), or an inability to speak English ($n = 1$).

Children were recruited to participate via newspaper and online advertisements, with flyers at area childcare centers and in local parks, through word of mouth from other participating families, or because they had participated in previous research projects with us.

Our sample was approximately 70% Caucasian, 8% African American, 4% Asian American, and 17% of mixed races. Information on socioeconomic status was based on the highest level of education for each parent. Overall the sample was very highly educated ($M = 17.96$ years of educational attainment, $SD = 1.97$). More than 80% of the parents had a graduate degree, 14.1% had a college degree, and 2.8% had a high school degree.

Parent survey and media diary

A parent completed a parent survey and a media diary. The parent survey consisted of 17 questions, asking demographic information, such as the parent's ethnicity and educational background, as well as information about the child's prior media exposure. Eight questions were on a 4-point Likert scale. A sample question is "How often has your child pressed computer keys or used a mouse to play a game? a) *Never; b) Once or Twice; c) About once a week; or d) Usually several times per week*." The parent survey was the source of the demographic information about our sample.

The media diary measured exposure time, organized by 30 min time blocks, beginning at 6 am and ending at 11:30 pm. Parents filled out two pages of the media diary, one representing a typical weekday and the other a typical weekend day. Parents were asked to check boxes to indicate both television and video exposure. These 30 min blocks were later summed to create a total exposure score.

Materials and apparatus

Object retrieval game

To create the object retrieval task, a partially animated hide-and-seek computer game designed for infants and toddlers was adapted from the *Curious Buddies: Hide & Seek* online game (NickJr.com, 2007). The original computer game consisted of four scenes, each including three characters – Bear, Cat, and Dog – from the Nick Jr. *Curious Buddies* video series. One of the scenes from the game, depicting a laundry room containing two laundry baskets and a clothesline on which several items of clothing were hung, was adapted for use in the present experiment.

The computer game was a model of a typical hide-and-seek game. During game play, each of the three Curious Buddy characters – Bear, Cat, and Dog – hid in one location in the laundry room. Specifically, Bear hid in the wooden basket, Cat hid in the blue basket, and Dog hid behind the pajamas. A child-like voiceover on the computer game prompted the player to look for the hidden Curious Buddies. The child pressed the spacebar to see where each Curious Buddy was hiding. In the video condition, a child viewed a recorded version of the computer game that someone had previously played. In the live condition a child observed through a one-way mirror as an adult demonstrated the same hide-and-seek game.

As in other object retrieval tasks, the entire laundry room scene from the game was recreated in an adjoining playroom. As seen in Fig. 1, the room contained a black and white checkered linoleum floor. A clothesline with a child's shirt, socks, pants, pajamas, and leotard hung in the back of the room. A "blue basket" and a "wooden basket" sat on the floor in front of the clothesline. In order to create a playroom and computer game that were as similar as possible, photographs of the two baskets and 5 pieces of clothing that were used in the actual playroom were inserted into the adapted *Curious Buddies* computer game, which modified the original animated computer game to a partially animated one.

Because toys representing the Curious Buddies characters were not commercially available to purchase, three-dimensional plush toys were constructed to look as similar as possible to them. Each character was about 38.1 cm tall by 21.6 cm wide. The characters were perceptually distinct; Bear was purple, Cat was bright pink, and Dog was lime green.

Computer game training

Because children often pressed the spacebar continuously during pilot testing, red paper cutouts of two small hands were taped to the top of the keyboard cover for the child to place his or her hands until it was time to press the spacebar so that responses were contingent on children's actions. To reduce the distraction caused by seeing all of the keys, a cover was created out of cardboard and placed on top of the keyboard so that only the spacebar button could be seen and touched (see Fig. 2).

An online Fisher-Price's (2009) game designed for infants and toddlers was used for training to ensure that children could use the spacebar when it was time to play the experimental game. This practice game required children to press the space bar for successful play. As part of the training, the experimenter demonstrated how to play the game by placing her hands on the cutouts of the two red hands on top of the keyboard before hitting the spacebar. The child was instructed to play the game until he or she could press the spacebar and touch the cutouts of the red hands without assistance.

Fig. 1. Curious Buddies playroom.

Fig. 2. Cardboard keyboard cover used for interactive computer game condition in the treatment room. When the Venetian blind behind the computer was open, a child could see directly into the playroom for the live observation condition.

Video cameras

Cameras were placed in both the Curious Buddies' playroom and the observation room. The camera in the playroom was positioned so that it could record exactly where the child searched for the Curious Buddies. The camera in the observation room was positioned so it could record the child's visual attention to the demonstration.

Procedure

Upon arriving, the parent and child were escorted to the treatment room where the parent read a brief description of the study, signed an informed consent form, and completed the parent survey that included demographic information and questions about their child's media use. Parents also completed the media diary of the child's media use during a weekday and a weekend day of a typical week. While the parent was completing the paperwork, the child became acquainted with the experimenters. The parent was present throughout the experiment but was instructed not to interact with his or her child during the demonstration.

Next, children in all three conditions were taken to the adjacent playroom where they were introduced to each of the three stuffed Curious Buddies characters: Bear, Cat, and Dog. Inside the playroom, the child was shown seven potential hiding places: inside the two baskets and behind the five items on the clothesline. Next the child was asked to point to each character when told its name to ensure knowledge of who each character was. If a child was unable to identify a character, the experimenter named the character again and then asked the child to point to that character. Finally, the child was told that he or she would be playing a hide-and-seek game with the Curious Buddies and was asked to go with the experimenter to the treatment room because the Curious Buddies were going to hide. When back in the treatment room, all children were told that they were going to watch (either on the computer, on the video, or through the window) as the Curious Buddies hid.

Children then participated in their respective condition. The three Curious Buddies hid in the same spots during each demonstration in all three conditions. That is, Bear always hid in the wooden basket, Cat always hid in the blue basket, and Dog always hid behind the pajamas on the clothesline, whether it was onscreen or demonstrated live via a one-way mirror into the playroom. To keep the size of the images constant, the computer monitor was used for both kinds of video demonstrations. After completing the demonstration, the child returned to the playroom and searched for the three hidden stuffed Curious Buddies.

Before entering the playroom for the first time, each child in the *interactive computer condition* received the computer-training task of learning to press the space bar to make something happen contingently on the screen. Once the child mastered the computer-training task, he or she was introduced to the playroom. Next the child returned to the treatment room. Once the child was standing in front of the computer, the experimenter said, “Now we are going to watch as the Curious Buddies play hide-and-seek” and the child began the interactive experimental experience. The child was again instructed to hit the spacebar and then touch the red hands to keep children from repeatedly banging the spacebar. Given that six repetitions of a video ameliorate the video deficit (Barr et al., 2007), six exposures were used in our study. Specifically, the experimenter demonstrated game play once and then the child played the game five additional times. Halfway through the demonstration, when all three Curious Buddies were on the screen, children were asked to point to Bear, Cat, and Dog on the screen. In this condition, pressing the spacebar made each Curious Buddy character appear from their hiding place in the laundry room, making the game contingent on the child's behaviors. Verbal prompts within the game (e.g., “Can you find Bear?”) cued the child to press the spacebar to find each Curious Buddy. When the child pressed the space bar, the game provided verbal reinforcement (e.g., “You're a great hide and seeker!”) as each character popped up from his hiding place. This condition lasted an average of 208.6 s ($SD = 45.96$).

In the *observational video condition*, the experimenter brought the child back to the treatment room after the child was introduced to the playroom. Once the child was standing in front of the computer monitor, the experimenter said, “Now we are going to watch as the Curious Buddies play hide-and-seek.” The child then watched a recording of the screen in which an experimenter had previously played the interactive computer game, a procedure that provides a reasonable approximation of how a video or television program is experienced in real life. Children watched this pre-recorded video that contained six repetitions of the game being played in order to match the amount of exposure provided in the interactive condition. Consistent with Troseth et al.'s (2006) procedure of keeping the verbal content and prompts constant in the comparison group, the same prompts used in our interactive video condition were heard (e.g., “Can you find Bear?”) and the same verbal reinforcement occurred when each character appeared from their respective hiding place (e.g., “You're a great hide and seeker!”). The video was paused halfway through the demonstration when all three Curious Buddies were on the screen, and children were asked to point to Bear, Cat, and Dog on the screen. Television programs designed for young children, such as *Blue's Clues*, also use such interactive prompts and reinforcers to sustain attention and interest (Calvert, 2006) so this approach served to maximize the ecological validity of the current study. This condition lasted an average of 170.91 s ($SD = 30.25$).

In the *live observation condition*, the experimenter brought the child back into the treatment room after the child was introduced to the playroom. Once the child was standing in front of the window, the experimenter said, “Now we are going to watch as the Curious Buddies play hide-and-seek.” The child then watched through the observation window as a second experimenter lifted each of the *Curious Buddies* from their hiding places in the actual playroom. The experimenter with the child in the treatment room recited the same prompts and verbal reinforcements that were in the *Curious Buddies* game. Consistent with prior research (Sharon & DeLoache, 2003; Troseth, 2003), only one exposure was provided for the live condition. This condition lasted an average of 29.77 s ($SD = 3.99$).

After experiencing their respective treatment condition, each child was immediately taken back to the playroom and asked to find each of the three Curious Buddies. If the child searched in a wrong location, the experimenter encouraged him or her to continue looking. The entire session, which lasted approximately 30 min, was videotaped for subsequent coding. When the search tasks were completed, each child was given a small toy, and the parent was reimbursed $20 for their time and traveling expenses.

Dependent variables

Looking time

Looking time was coded while each child played the interactive computer game, watched the video, or watched the live adult through the observation window as the Curious Buddies appeared from their hiding places. Looking time was measured as the total amount of time the child's attention was "on task." Attention was defined as being "on task" if the child was looking at the screen (for interactive and observational conditions) or through the one-way mirror (for the live condition), looking at the keyboard in the interactive condition, or looking at the experimenter in all conditions. The child's attention was coded as "off task" if the child was looking elsewhere (e.g., at their shoes). Looking time was calculated by dividing total "on task" attention time by the total length of the presentation.

Twenty-five percent of the sample was double coded for reliability. Intraclass correlations for reliability were $r = .93$, within the acceptable range of .7 to 1.0. Due to camera malfunction or a parent blocking the camera, looking time could not be coded for seven children. Mean attention scores by condition were substituted for the seven missing attention scores.

Object retrieval performance

After the demonstration, each child was asked to search for the three Curious Buddies. Using a coding system adapted from one developed by Troseth and DeLoache (1998), we coded for the child's number of errorless retrievals of the Curious Buddies. When the children entered the playroom, they frequently dashed around the room looking for the Curious Buddies, as occurs during the real game of hide-and-seek. Therefore, we counted the number of Curious Buddy characters found in the first three places that a child looked. Since there were three hidden Curious Buddies in our game, the maximum score a child could receive was 3 points. If a child perseverated (looked where they had previously searched) or searched in a location in which a Curious Buddy was not hiding, no credit was given. For example, a child received one point each time he or she found a Curious Buddy in a new location (e.g., Cat in the blue basket). If the child searched in that spot again, no credit was given. Two coders scored 25% of the videos ($n = 18$) to assess inter-observer reliability. Intraclass correlations for reliability were $r = 1.00$, which is within the acceptable range of .7 to 1.0.

Results

Preliminary analyses

The parent survey included information about the child's previous media experiences. Of the 64% of children who had previously used a computer, 43% started using a computer at 18 months or younger, 28% began using a computer between 19 and 29 months, and 28% began using a computer after 30 months. Older children were more likely to have interacted with a mouse or computer keys than were younger children, χ^2 (3) = 7.87, $p < .05$. None of the toddlers had been exposed to the Curious Buddies game. Results from the media diary indicated that toddlers were exposed to an average of 2 h and 30 min per day ($SD = 2$ h 10 min) of total television and video programming, a figure that is consistent with media exposure patterns for children of this age (Rideout & Hamel, 2006).

Preliminary analyses indicated that sex, parental education, household television usage, and prior child use of a computer did not differ across age or condition and did not predict object retrieval or percent looking time scores. Therefore, these data were not used in subsequent analyses.

Looking time

The overall percent of looking time was very high for children across all three conditions ($M = .91$, $SD = .13$). A 2 (age: 30 months, 36 months) × 3 (condition: interactive, observation, live) analysis of variance (ANOVA) with percent looking time as the dependent variable yielded a main effect of condition, $F(1, 66) = 12.38$, $p < .01$. Tukey HSD post-hoc comparisons indicated that children in the live observation condition ($M = .99$, $SD = .02$) attended significantly more than those in the video observation condition ($M = .84$, $SD = .17$), $p < .01$. The mean scores of children in the interactive condition ($M = .91$, $SD = .11$) fell between the other two means and were not significantly different from either of the other two conditions.

Object retrieval performance

Pearson zero order correlations indicated that the percent looking time was associated with the object retrieval performance, r (72) = .25, $p < .05$. Because percent looking time was different across conditions and related to object retrieval scores, object retrieval performance was analyzed in a 2 (age: 30 months, 36 months) × 3 (condition: interactive, observation, live) ANCOVA with percent looking time as a covariate. There was a significant main effect of condition, $F(2, 65) = 3.44$, $p = .04$, partial $\eta^2 = .10$ and a trend for age, $F(1, 65) = 3.38$, $p = .07$, partial $\eta^2 = .05$. As predicted, post-hoc ANCOVA comparisons indicated that children in the live observation ($p < .01$) and interactive conditions ($p < .05$) were significantly more successful at finding the hidden Curious Buddy characters than were those in the observational video condition, even after controlling for percent looking time (see Table 1). As expected, object retrieval scores did not significantly differ between the live and interactive conditions ($p = .90$), even when controlling for the amount of looking time (see Table 1). As expected, 36-month-old children tended to perform better than the 30-month-old children ($M = 2.58$, $SD = .55$ vs. $M = 2.31$, $SD = .71$).

Types of errors

Table 2 depicts the number of errorless retrievals and types of errors made by children at each age group by condition. Thirty-seven children successfully found all three Curious Buddy characters in their first 3 searches. As has been shown in previous research (Sharon & DeLoache, 2003; Suddendorf, 2003), most children who made mistakes made perseveration errors in which they looked in the same location for a Curious Buddy as the one that they had previously searched for another Curious Buddy. Of the children that did not find all three Curious Buddy characters ($n = 35$) in their first three tries, the majority of children made perseveration mistakes ($n = 29$ for 1 perseveration error; $n = 2$ for 2 perseveration errors); two children searched in locations where a Curious Buddy character was not hiding; and two children could not remember where the third Curious Buddy character was hiding.

Table 1
Adjusted object retrieval scores means and standard errors by condition and age.

Age group	Condition	Mean	Standard error
30 months	Video observation	1.84	.19
	Computer interaction	2.42	.17
	Live observation	2.67	.18
36 months	Video observation	2.33	.17
	Computer interaction	2.67	.17
	Live observation	2.75	.18

Note: The maximum possible search score is 3 for each Curious Buddy.

Table 2
Number of children with errorless trials or by type of error for the search task.

Age group	Condition	No errors	Perseveration error	Wrong location error	Unable to find buddy error
30 months	Video observation	3	8	0	1
	Computer interaction	5	6	1	0
	Live observation	7	4	0	1
36 months	Video observation	4	7	1	0
	Computer interaction	8	4	0	0
	Live observation	10	2	0	0
Total		37	31	2	2

Discussion

The purpose of this study was to examine the role that interactive computer experiences play in very young children's skills at transferring their learning from a search game presented on a screen to a real playroom. As expected, children who played the interactive computer game and those who observed the live demonstration were similar in object retrieval scores, and both of these conditions were superior to the observational video condition, thereby providing evidence that the video deficit can be ameliorated with interactive experiences. Consistent with prior research (e.g., Troseth & DeLoache, 1998; Troseth et al., 2006), older children performed slightly better than younger children did. Our findings suggest that when faced with a cognitively challenging task, both developmental factors and interactivity are important for children's success.

Our results can be interpreted using dual representation theory, in which contingency to children's actions improves their skills at transferring the symbols that are on a screen to real-life experiences. Troseth et al. (2006) were the first to argue that 2-year-old children do not transfer information from televised stimuli to real-life activities because television does not respond contingently to their actions. A socially contingent interaction with a live adult, such as calling a child by name, by contrast, increases the likelihood that he or she will understand that information presented symbolically on a screen represents the real world (Troseth et al., 2006).

In the present study, the characters in the live and in the interactive computer condition responded contingently to what a child did, creating a “social” interaction with either the live adult or the symbolic Curious Buddies characters. Regardless of whether this “social” interaction occurred live with an adult or with the Curious Buddies characters while playing the interactive computer game, children performed the object search task equally well. By contrast, during most television and video presentations, as was the case in our observational condition, there is a lack of contingent replies to children's actions. Past research finds a video deficit effect, as we did here, when comparing only a video observation condition with a live presentation (Anderson & Pempek, 2005; Barr & Hayne, 1999, Troseth & DeLoache, 1998). Taken together, our findings add to the body of literature that suggests that interaction provides cues that help children bridge the gap between onscreen symbolic experiences and their referents in real-life.

Not only did performance differ by condition, children's attention to the demonstrations also differed by condition. Children who watched the live demonstration attended equally as much as those children who played the interactive computer game, but significantly more than those who watched the video. While attention was quite high overall, this relative decrease in attention by the observational video condition when compared to the live condition indicates that the interactive qualities that occur in the live condition are enhancing children's attention to the demonstrations. Even so, it is notable that the computer condition did not differ from either condition in attentional interest, yet it was comparable to the live condition and better than the observational condition for object retrieval success. These findings suggest that there is something about interactivity *per se* that improves learning over simply looking at the material, a finding that has been documented in research with preschool-aged children (Calvert et al., 2007).

Interactivity, then, may be an important part of the puzzle that has been missing in understanding the video deficit. Until now, closed-circuit television experiences have been used to examine the role of interactivity (e.g. Troseth, 2003; Troseth et al., 2006). Although interactions on applications like skype, in which a second individual can interact contingently with a child on a screen from another location, now occur, this type of experience does not typically convey educational information to children. On the other hand, the presence and use of computers in young children's homes is very prevalent (Calvert et al., 2005) and provides a logical way to show very young children that a video screen will respond to what they are doing and provides an additional retrieval cue to enhance transfer of information to the real world.

Previous studies using the object retrieval task paradigm required children to watch events on a screen while one toy was hidden, and children were then immediately given the opportunity to find the toy (e.g., Troseth, 2003). In these prior studies, an experimenter always hid the toy, and the toy was an object that the child was introduced to before each search task began (e.g., Troseth & DeLoache, 1998). In the current study, the computer game was adapted from an actual computer game available on the Internet for young children to play. In our partially animated computer game, three objects appeared from hiding places, which meant that our task was more naturalistic, and also more complex, than were the ones previously used by DeLoache and colleagues (e.g., DeLoache, 1991; Troseth, 2003; Troseth & DeLoache, 1998).

The object retrieval task used in this study required children to keep three Curious Buddies and their hiding places in mind simultaneously, a challenging task that places considerable demand on children's working memory as it increases the cognitive load. Therefore, it is not surprising that our task was still somewhat challenging even for 30- and 36-month-old children. At both ages, many children did make errors when searching for the three Curious Buddy characters, probably as a result of the increased complexity of this task. Consistent with other research (e.g., Sharon & DeLoache, 2003), the most common type of mistake was perseveration errors. Even so, more than half of the children found the three Curious Buddy characters without making any errors at all.

Although the live demonstration condition required only one exposure for successful performance, repeated exposure to the interactive computer condition was also superior to repeated exposure to the video observation condition. Children in the live observation condition did not need to transfer information across live and symbolic domains, but those in the interactive and video observation conditions did. When an observational video task is cognitively challenging, repetition alone does not seem to entirely ameliorate the video deficit (see also Barr & Wyss, 2008). For instance, 15- to 16-month-old infants were able to imitate the actions on a touch screen when they observed an adult demonstrate it six times on a touch screen (2D–2D), but they had difficulty transferring that 2D information to a real 3D object (Zack, Barr, Gerhardstein, Dickerson & Meltzoff, 2009). Similarly, for a more complex task where children had to find three Curious Buddy characters in our study, even older children had difficulty transferring information after observing video presentations six times.

The present study also provides the first examination of object retrieval from a partially animated computer presentation. Prior studies of the video deficit typically used photographs or videos of actual experiences rather than animated screen displays. The more realistic the iconic representation is, the more likely a toddler is to imitate actions from a book (Simcock & DeLoache, 2006) or to retrieve objects from a room (DeLoache, 1991). By 2.5 years, however, due to multiple book reading experiences, children are able to use a variety of drawings to transfer information (DeLoache, 1991; Simcock & DeLoache, 2006). Even so, the video deficit remains a challenge for 3-year-old children when the task is difficult (Flynn & Whiten, 2008; Gerhardstein et al., 2009; McGuigan et al., 2007). Given that a great deal of television and computer game content is provided in an animated format, examining transfer of learning from this type of display is important.

At an applied level, our results provide guidance to the makers of screen products that are designed for very young children. Because animation and the type of contingency used here (i.e., pressing a key to cause an action) are typical features of many interactive websites, computer software games, and videogame consoles designed for infants and toddlers, the results may be particularly informative for the production of educational media content for this young audience. Specifically, since we know that infants and toddlers learn better from contingent screen experiences than from non-contingent observational experiences, producers may want to create more interactive educational experiences for very young children in which the products respond contingently to the child's behavior. Producers will also need to guide parents about how to teach their young children to take turns with computer content in those very early computer interactions so that their children do not just hit the keyboard repeatedly, as we noticed was done often with young children during our pilot testing. In the present experiment, the Curious Buddies game also took advantage of the interest in hide-and-seek games during early childhood, a task that builds on children's enjoyment of specific kinds of real-life experiences while extending them to a screen.

The main limitations of this study were the concurrent use of three toys in the object retrieval game and the lack of randomization in where the Curious Buddies hid. Due to the way that computer games are actually played, children did not interact or play as one Curious Buddy appeared and then immediately enter the playroom to find that particular hidden Buddy. Rather, after watching all the Curious Buddies hide, children entered the playroom and were asked to find the three Curious Buddies. While this is a limitation of this study, the approach is consistent with traditional hide-and-seek games that children of this age play in which they search for all the other players that are hidden at once. Indeed, that is the way that many children played our game, suggesting that there was some transfer of actual hide-and-seek game play rules to the study. Moreover, given that this game was adapted from an actual online computer game, this study provides information about how children learn from computer games that are currently available for this audience during early development.

In conclusion, our findings suggest that all screen experiences are not equal. In particular, the contingent reinforcements and interactive capabilities provided by a computer game aided young children's learning from a screen such that object retrieval was comparable to that of viewing a live adult, thus ameliorating the video deficit, and both of these conditions performed better when compared to observing the presentation as a video. Indeed, computer experiences help very young children bridge a critical knowledge gap: that the events they interact with on a screen are relevant to their lives, and hence, can be transferred to their real-life experiences.

Acknowledgements

This research was supported by grant no. 0623871 from the National Science Foundation to Sandra L. Calvert. We thank Marta Perez, Yevdokiya Yermolayeva, Samantha Goodrich, Renee Goldman, Alex Verdaguer, and Katrina Pariera for their assistance with data collection and coding for this study. We also thank Rusan Chen for his assistance with the statistical analysis, and Rob Ellis for his assistance in programming the computer game. Finally, we thank the families and children who made this research possible.

References

Anderson, D. R., Bryant, J., Wilder, A., Santomero, A., Williams, M., & Crawley, A. M. (2000). Researching Blue's Clues: Viewing behavior and impact. *Media Psychology*, *2*, 179—194.

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

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

Barr, R., Muentener, P., Garcia, A., Chavez, V., & Fujimoto, M. (2007). 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.

Calvert, S. L. (2006). Media and early development. In K. McCartney, & D. A. Phillips (Eds.), *Blackwell handbook of early child development* (pp. 508—529). Malden, MA: Blackwell.

Calvert, S. L., Rideout, V. J., Woolard, J. L., Barr, R. F., & Strouse, G. A. (2005). Age, ethnicity, and socioeconomic patterns in early computer use: A national survey. *American Behavioral Scientist*, *48*, 590—607.

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.

Calvert, S. L., Strong, B. L., Jacobs, E. L., & Conger, E. E. (2007). Interaction and participation for young Hispanic and Caucasian children's learning of media content. *Media Psychology*, *9*, 431—445.

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.

DeLoache, J. S. (1987). Rapid change in the symbolic functioning of very young children. *Science*, *238*, 1556—1557.

DeLoache, J. S. (1991). Symbolic functioning in very young children: Understanding of pictures and models. *Child Development*, *62*, 736—752.

DeLoache, J. S., & Burns, N. M. (1994). Early understanding of the representational function of pictures. *Cognition*, *52*, 83—110.

Fisher-Price (2009). Laugh and Learn™ Peek-a-Boo! game. Retrieved February 28, 2009. http://www.fisher-price.com/us/playtime/games/infantGames_B_BS.asp.

Flynn, E., & Whiten, A. (2008). Cultural transmission of tool use in young children: A diffusion chain study. *Social Development*, *17*, 699—718.

Garrison, M., & Christakis, D. (2005). *A teacher in the living room: Educational media for babies, toddlers, and preschoolers.* Menlo Park, CA: Henry J. Kaiser Family Foundation.

Gerhardstein, P., Dickerson, K., Zack, E., & Barr, R. (2009, October). Learning from screen media in older infants: An extension of the video deficit effect. *Developmental Psychobiology*, *51*, 584.

Goodrich, S., Pempek, T., & Calvert, S. L. (2009). Formal production features in infant programming. *Archives of Pediatrics and Adolescent Medicine*, *163*(12), 1151—1156.

Kirkorian, H. L., Wartella, E., & Anderson, D. R. (2008). Media and young children's learning. *Future of Children*, *18*, 63—86.

McCall, R. B., Parke, R. D., Kavanaugh, R. D., Engstrom, R., Russell, J., & Wycoff, E. (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*, 1—94.

McGuigan, N., Whiten, A., Flynn, E., & Horner, V. (2007). Imitation of causally-opaque versus causally-transparent tool use by 3- and 5-year-old children. *Cognitive Development*, *22*, 353—364.

NickJr.com (2007). Curious Buddies: Peek-a-boo and hide-and-seek. Retrieved January 4, 2007. http://www.nickjr.com/playtime/cats/games/curi/curi_peekaboo.jhtml.

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

Rafaeli, S. (1988). Interactivity: From new media to communication. In R. P. Hawkins, J. M. Wiemann, & S. Pingree (Eds.), *Advancing communication science: Merging mass and interpersonal processes* (pp. 110—134). Newbury Park, CA: Sage.

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., Vanderwater, E. A., & Wartella, E. A. (2003). *Electronic media in the lives of infants, toddlers, and preschoolers.* Menlo Park, CA: Kaiser Family Foundation.

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.

Sharon, T., & DeLoache, J. S. (2003). The role of perseveration in children's symbolic understanding and skill. *Developmental Science*, *6*, 289—297.

Simcock, G., & DeLoache, J. S. (2006). Get the picture? The effects of iconicity on toddlers' re-enactment from picture books. *Developmental Psychology*, *42*, 1352—1357.

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.

Troseth, G. L. (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.

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.