Do very young children learn from video?

¿Aprenden los niños muy pequeños de las imágenes de video?

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Abstract

This paper summarizes research on infants' early behavior toward televised images, and explores a "video deficit" in toddlers' learning from video. A shift in recognizing video images as representations allows older children to learn educational content from television programs and to distinguish realistic programming (e.g., the news) from fantasy (e.g., cartoons and dramas).

Keywords: Representations, images, television, learning.

Resumen

Este artículo resume investigaciones sobre la conducta de los bebés hacia las imágenes televisivas, y explora un "déficit" en el aprendizaje de niños pequeños por medio de estas imágenes. Un giro en el reconocimiento de las imágenes de video como representaciones permite a los niños mayores aprender contenidos educativos de programas televisivos y distinguir la programación basada en la realidad (por ej., las noticias) de la basada en la fantasía (por ej., caricaturas y ficciones).

Palabras clave: Representaciones, imágenes, televisión, aprendizaje.

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A characteristic of human cognition is that we learn not only through direct experience but also by means of other people's words and a variety of symbolic artifacts—representational objects such as maps, pictures, and diagrams that record and communicate information (DeLoache, 2000; Tomasello, 1999). One symbolic medium on which adults in the developed world rely for information is video. On September 11, 2001, many adults spent the whole day watching television, seeking information about the tragic events unfolding in New York City. While parents tried to keep up with the news, their young children may have been exposed to repeated images of disintegrating skyscrapers and weeping people searching for their relatives. An important question for parents and teachers concerned with children's learning and with protecting them from harm is how children interpret pictures on television. Do children believe images on a TV screen are real events? Or do they interpret such images as fantasy--perhaps as scenes from a Hollywood action movie?

Research indicates that children's response to video changes as they gain experience with television and learn about the real world (e.g., Wright, Huston, Reitz, & Piemyat, 1994). At first, infants respond to video as if it was real, but toddlers apparently interpret video as distinct from reality (Troseth, 2003b), which may affect their learning from educational television. As they begin to recognize video images as *representations* or symbols of events, older children begin to learn educational content from television programs. Mature understanding of video by school-aged children involves the flexibility to distinguish realistic programming (e.g., the news) from fantasy (e.g., cartoons and dramas).

Full knowledge about video takes time to develop because it involves both children's perception of 2-dimensional images and their concepts regarding how these images are different from but related to reality. Perception of differences requires noticing the absence of depth cues in video, including the lack of motion parallax (moving one's head while looking at the picture does not change what is visible) and convergence (there is little or no difference in the images to the two eyes—DeLoache, Pierroutsakos, & Troseth, 1996). Although infants (even newborns) can perceive the difference between 2- and 3-dimensionality, only gradually do they develop conceptual knowledge regarding how video differs from reality. Developing the concept of a video image as a kind of picture, a *physical representation* of an event, allows children to learn about the event without directly perceiving it. Learning from video in this way involves mentally representing both the 2-dimensional image on a TV screen and the real event it stands for, achieving what DeLoache (1987, 2002) terms *dual representation*. To respond appropriately to a video image, a viewer must hold in mind both the content of the image and information indicating that this is merely a representation (e.g., the glass surface of the screen, the surrounding frame, logos, and buttons, flatness cues from the image itself, etc.).

The complexity of video images as representations

Very young children are confused by the dual nature of video and pictures. For instance, during one of my studies, a 2-year-old participant was watching a videotape of herself and her family building a tower of books and blocks. She retrieved a block and tried to hand it to the people on the TV screen, saying, "Here." Jaglom and Gardner (1981) describe a 2-year-old going to get a paper towel after seeing an egg break on television. Older preschoolers continue to express some confusion about video images and pictures, as when 3-year-olds told Flavell and his colleagues that a bowl of food in a video or picture would spill if the TV or photo were turned over (Flavell, Flavell, Green, & Korfmacher, 1990). These young viewers recognized the contents of the images—the blocks, the broken egg, the bowl of food—but did not seem to clearly hold in mind that what they saw were depictions.

The many different symbolic relations that are possible between video and reality present another challenge for children (Troseth, Pierroutsakos, & DeLoache, 2004). First, video can depict *ongoing, current reality*; the LCD flip-screens of parents' video cameras (and security camera video monitors in stores) offer children fascinating glimpses of themselves "on TV". Video also can present *real events occurring far away* (e.g., a soccer match occurring in a stadium in another city). Video serves as a record of *real events of the past*, such as the speeches of presidents and prime ministers. Additionally, video can depict *events that bear little or no relation to reality*, including dramas and cartoons. Computer animation can make on-screen fantasy (e.g., humans interacting with dinosaurs) look convincingly real. In developing a mature understanding of video, children must learn to identify and discriminate the various relations between video and reality (Troseth, 2007).

Another aspect of complexity in interpreting video images—even realistic ones—involves *representational specificity*. The same image can serve as a specific or a generic representation, depending on the intention of the person who filmed the video and/ or the person who displays it (DeLoache, & Burns, 1994; c.f. Goodman, 1976; Rakoczy, Tomasello & Striano, 2005; Troseth, 2003b). For instance, in a video of zoo animals, the image of a mother panda and her baby can represent the kind "panda" *in general*, but in a newscast, the same image could depict a *specific* mother animal that has just given birth in captivity. Representational specificity is important in determining how to use a particular image. Watching the zoo video, one might learn general facts, such as the size of newborn pandas. Viewing the newscast, however, might guide one's current behavior (e.g., planning a trip to the zoo to see the baby panda). News and weather reports provide "episodic knowledge" that can be immediately applicable in updating one's mental representation of current reality.

Detecting the intended function of a video image relies both on world knowledge about the contents of the video and on awareness of form cues typically found in the various *genres* of television (such as voiceovers and distant, shaky camera footage for breaking news, and music and close-ups for dramas). The youngest viewers would have little background in either of these areas of knowledge.

Infants' perception of and behavior toward video

Although lacking experience, babies are highly competent at one skill needed to understand video: they perceive the similarity between a 2-dimensional image and the real 3-dimensional entity that is depicted (e.g., Barrera & Maurer, 1981b; DeLoache, Strauss, & Maynard, 1979; Hochberg & Brooks, 1962). Five-month-olds appear to recognize their own moving legs on video (Rochat & Morgan, 1995) and they respond to the video image of another person with smiles and increased activity, much as they would to the actual person (Bigelow, 1996; Bigelow & Birch, 2000; Gusella, Muir, & Tronick, 1988; Hayes & Watson, 1981; Muir, Hains, Cao, & D'Entremont, 1996; Murray & Trevarthen, 1985). Nine-month-olds produce similar emotional expressions to video of objects and people as they do the real entities (Diener, Pierroutsakos, Troseth, & Roberts, 2008). For instance, they show fear in response to scary masks and positive affect toward an electronic toy and a person playing peek-a-boo.

Similarly, 12-month-old infants can interpret the emotional responses of people on video (Mumme & Fernald, 2003). Infants were shown a 20-second video clip of an adult expressing fear of one of two toys. When given the opportunity to play with it, the infants avoided that toy (compared to the other one) and showed more negative affect toward it. Thus, it is clear that infants find video presentations meaningful and that they are capable of extracting information from video (although they often do not do so -a paradox that will be described later). Furthermore, they respond to video with the same kinds of emotions that they produce in response to actual objects and events.

Infants also *discriminate* images of people and objects from the real things. Four- to six-month-old infants smile more at a real person than at a live video view of that person—even though the person is equally responsive to the baby in both cases (Hains & Muir, 1996). Nine-month-olds differentiate video images of people, objects, and events from their real counterparts, looking longer at and producing stronger emotional reactions to a live presentation of these entities than at a video of them (Diener *et al*., 2008). Similar results have been found with still pictures (e.g., DeLoache *et al*., 1979), with even newborns perceiving the difference between 2-D pictures and 3-D objects (Slater, Rose, & Morrison, 1984). Thus, perception of video and other pictures appears relatively automatic—young infants are able to both recognize similarities and discriminate differences between real objects and images of those objects.

However, there is evidence that infants do not understand the implications of the similarities and differences that they perceive. Researchers have reported infants' odd behaviors toward pictorial images. For instance, 9-month-olds looking at a picture book with their parents “scratched at the pages as if trying to lift the picture from the page” (Murphy, 1978, p. 379) and a 16-month-old tried to step into a picture of a shoe (Perner, 1991). To systematically explore the prevalence and meaning of this behavior, DeLoache, Pierroutsakos, Uttal, Rosengren, and Gottlieb (1998) showed 9-month-old infants in the United States and the Ivory Coast realistic photos of objects (e.g. a bottle, a rattle, common African objects). In a similar procedure with video, Pierroutsakos and Troseth (2003) sat 9-month-olds directly in front of a TV screen and showed them a video of a woman's hand placing objects one at a time on a tabletop. We included two moving toys—a rocking Big Bird and a mechanical snail that lumbered across the screen.

Every one of the 9-month-old infants in the original picture and video studies, and most children in several replications, manually investigated the pictured objects, rubbing and hitting the surface of the pictures or video screen. As can be seen in Figure 1, they even grasped at the pictures as if trying to pick up the depicted objects (the infant's grasping fingers are visible in the inset picture). The children were particularly persistent with the moving objects, often following the snail across the TV screen while repeatedly grasping at it.

Why do 9-month-old infants manually investigate objects on video? Apparently this is not because infants cannot perceive the difference and fully expect to be able to pick up depicted objects. When Diener *et al*. showed 9-month-olds real and videotaped people, objects, and events, the babies looked reliably longer at the live view than at the video. Children of this age also reached for an object in preference to its picture, showing that they noticed the difference (DeLoache *et al*., 1998). Manual behavior may result from the dual nature of pictorial images, which in many ways look like real objects, but in other ways do not (lack of motion parallax and binocular disparity, etc.). Nine-month-olds evidently do not understand the significance of these perceptual differences for their behavior. They respond to a depicted object as if it were real, attempting to manually investigate it. Infants' lack of surprise when they are unable to access the contents of images indicates that they are trying to figure out what they are, just as they attempt to manually explore other aspects of the environment.

Fig. 1: A 9-month-old trying to grasp an object pictured on TV. In the inset (side view) picture, the infant's pincer grasp is visible.

With age, manual investigation decreased toward both pictures and video (DeLoache *et al*., 1998; Pierroutsakos & Troseth, 2003). Older infants (19-month-olds) were more likely to point at and vocalize about the objects in video images and pictures instead of manually exploring them. Thus, the tendency to physically explore the surface of the image is gradually replaced by communication about the depicted, real-world referent, similar to the way that children start directing others' attention to real objects at around 10 months (Carpenter, Nagell, & Tomasello, 1998). Through experience, infants learn that a depiction is not a real, manipulable object. They learn to point to and label objects in video and pictures as their parents do (Gelman, Coley, Rosengren, Hartman, & Pappas, 1998; Ninio & Bruner, 1978). Only in rare instances do older children lose sight of the fact they are viewing a depiction.

A very important development occurs when children realize that 2-dimensional images refer to something else. Preissler and Carey (2004) taught 18- and 24-month-old children the new word “whisk” by repeatedly labelling a line drawing of this kitchen implement. Then the researchers presented the picture along with a real whisk and asked the children to show them the whisk. The children almost always indicated either the real object, or the object and the drawing, not the picture alone (the item that actually had been paired with the word). Control conditions ruled out the possibility that children would choose *any* object, or any *novel* entity, in response to the question. Evidently when children observed the adult labelling the picture, they realized that the label referred to the depicted object, not just to the picture; that is, they interpreted the picture referentially (see also Ganea, Pickard, & DeLoache, 2008). By 18 months of age, children have begun to appreciate the symbolic nature of pictures. However, the same kind of research has not been done with video.

Preissler and Carey's picture naming is similar to what many parents do naturally while reading picture books with toddlers. Because of this prior experience, the children may have recognized the researcher's intentions to refer to a real object by labelling its picture. However, parents may not habitually engage in the same kind (or amount) of naming of objects in videos, and it is an empirical question whether toddlers would recognize the referential nature of video images at the same age. Yet even without recognizing a video as a representation, children could be reminded of an object by its appearance on video; this is what may have happened when my young participant saw herself and her parent building a tower of blocks on a home video, retrieved a block, and attempted to hand it to her parent on TV.

Learning from video

The fact that infants can recognize objects and events on video suggests that they might learn from the medium, even before they recognize its referential nature. For instance, 12-month-olds learned to avoid one of two toys that had scared a person on a video (Mumme & Fernald, 2003). However, after trying unsuccessfully to interact with people and objects on video, older infants and toddlers might develop the concept that video is *not* real, causing video to temporarily lose its effectiveness as a teaching medium. In other domains, toddlers are thought to develop experience-based, temporary initial conceptions that affect their processing of information; two examples are gender schemas (e.g., Bauer, 1993; Ruble & Martin, 1998) and biases regarding word learning (Hollich *et al*., 2000; Imai & Haryu, 2004; Saylor & Sabbagh, 2004).

There is evidence that something like the above happens across the first two years of life, with younger babies more readily learning from video than older infants and toddlers do. This pattern can be seen in studies of early imitation. Barr and her colleagues examined infants' imitation of a sequence of actions that an adult performed on a toy. The person demonstrating the series of 3 actions either was present in the children's living room, or appeared on video on the family's television. The youngest children that Barr and colleagues could test (6-month-olds) imitated just as much after watching the person on video or “face to face” (Barr, Muentener, & Garcia, 2007). In both cases, these very young babies required 6 repetitions of the demonstration to imitate. Older infants and toddlers (12- to 30-month-olds) had more efficient memories, imitating a live modeler after just 3 repetitions (Barr, Dowden, & Hayne, 1996; Barr & Hayne, 1999; Hayne, Herbert, & Simcock, 2003). However, after watching the same demonstration by a person on video, children in these older age groups imitated significantly less (Barr & Hayne, 1999; Hayne *et al*., 2003; McCall, Parke, & Kavanaugh, 1977; see Krcmar, Grela, & Lin, 2007, for a similar age difference in learning words from video).

One factor that might affect older infants' learning is their growing awareness of social behavior, including the contingency between their own actions and the responses of others. Starting at 2 months of age, young infants display the same kinds of social behavior (e.g., smiles, animated movements of arms and legs) toward people on video as they do in face-to-face interaction (Bigelow, 1996; Gusella, *et al*., 1988; Hayes & Watson, 1981; Muir, *et al*., 1996; Murray & Trevarthen, 1985) and responding the same to *live* and to *pre-taped* (non-contingent) video of their talking and smiling mothers (Marian, Neisser, & Rochat, 1996). However, between 4 and 8 months, infants become sensitive to disruptions in interpersonal contingency (Bigelow, MacLean, & MacDonald, 1996; Hains & Muir, 1996). After watching a pre-taped video of a person, Hains and Muir's (1996) participants were less attentive and responsive to live video and to live, face-to-face interaction than were infants who received these contingent conditions first. Hains and Muir proposed that infants' expectation that a videotaped person will be unresponsive affects their attentiveness when that person later attempts to serve as a social partner. Apparently, expectations of non-contingency may endure, affecting infants' responses to people on video as much as a week later (Bigelow & Birch, 2000).

Missing social cues (including contingency) apparently affected infants' learning in a study of speech perception abilities using video. At an age when infants' speech perception narrows toward their parents' language, a group of 9-month-olds maintained the ability to discriminate non-native (Mandarin Chinese) speech sounds after a Mandarin speaker interacted with them face-to-face for 5 hours across the course of a month; however, other 9-month-olds lost this ability after watching the same speaker on video for the same amount of time (Kuhl, Tsao & Liu, 2003). In both cases, the speaker made apparent eye contact with the child, looking at and talking about books and toys. Infants who watched the Chinese speaker on the video were much less attentive than the children who observed a real person. Kuhl and her colleagues conclude that social cues available in the direct interaction both kept infants' attention and indicated what the people were talking about, factors that were important to infants' learning of speech information. Certainly, the 12 sessions gave infants ample time to form expectations of non-responsiveness regarding the people on video.

The responsiveness of a person on video also seems important to toddlers. In two studies, researchers used closed-circuit video to enable a person on TV to respond contingently to viewing children. In one, a person on video interacted with the child and parent for 5 minutes. She told children where to find a sticker and commented on the sticker's appearance, showing she could share attention with the child and refer to an aspect of the real world. Following this experience, 24-month-olds used information provided by the person on video to solve a problem (Troseth, Saylor, & Archer, 2006; see also Nielsen, Simcock, & Jenkins, 2008). When the person on video was non-responsive, children did not use the information she offered.

Word Learning from People on Video?

Toddlers' ideas about people on video might affect their learning of important educational content, such as vocabulary, from television. Early word learning involves children's sensitivity to referential social cues offered by others (Baldwin & Tomasello, 1998). In a recent word learning study, 24- and 30-month-olds failed to learn a word from a person on a video who uttered the word while gazing into an opaque bucket containing a target object and away from a visible distracter. However, toddlers used these cues when offered by a person who was present (Troseth, Saylor, & Strouse, 2010). Even when a person's referential cues were straightforward (gaze toward one of two visible toys), 22- to 24-month-olds learned a word less often on video trials compared to on trials when a speaker was present (Krcmar *et al*., 2007).

Additionally, 30- to 35-month-old children did not learn verbs after repeatedly watching events on video narrated by voiceovers; they did learn when the first two video demonstrations were replaced with live social interaction (an adult using a doll or puppet to demonstrate and label the action—Roseberry, Hirsh-Pasek, Parish-Morris, & Golinkoff, 2009). Only children over age 3 learned the verbs from video alone.

However, word-learning studies indicate that children need not be *involved* in a social interaction to learn from another person. Children also learn as *onlookers* to conversations taking place around them. Specifically, while "overhearing" an exchange between two people, 18-month-olds used a speaker's social behavior (e.g., eye contact and contingent interaction directed toward the other adult) to learn words, learning as well as children did after being directly addressed by the speaker (Akhtar, Jipson & Callanan, 2001; Floor & Akhtar, 2006).

Would the same hold true for overheard conversations occurring on video? We recently found that 30-month-old toddlers learned a word from "overhearing" the social exchange of two people on video, but children of the same age did not learn the word when a person on video directly addressed them (O'Doherty, Troseth, Shimpi, Goldenberg, Akhtar, & Saylor, 2009). We think the difference involves the presence of an intact social interaction in the first case but disrupted interaction in the latter case. During the interaction between adults on video, the speaker labeled and manipulated a novel object before handing it to the confederate, who imitated the speaker's actions (Akhtar's original procedure). Thus, children watched two people who were obviously engaged and sharing information. We hypothesized that children learned as onlookers because they recognized that knowledge was being shared between the partners (and possibly imagined themselves as part of the exchange—Herold & Akhtar, 2008). In contrast, when a person on a pre-taped video addresses a viewer from a video screen, he or she can neither share objects nor be responsive if children try to engage in interaction. Thus, the presence or absence of social responsiveness may affect toddlers' word learning from video.

Representation and learning from video

Thus far, we have argued that young children's initial concepts may temporarily affect their learning from video. Although young infants may learn by responding as if a video image was real, older infants and toddlers may distinguish video as "not real", lessening the medium's instructional value. In research with this age group, learning is consistently poorer with video than when live events are the stimuli—a pattern of results described as "the video deficit" by Anderson and Pempek (2005). In contrast, mature viewers know that video is a symbolic medium that can provide useful information. For instance, when adults watch the news, they form a mental representation of real events happening outside the television screen.

Troseth and DeLoache (1998) examined at what age young children also use video in this way, employing a general procedure used previously with other symbolic media (pictures, scale models, and maps—DeLoache, 1987; DeLoache & Burns, 1994; Marzolf & DeLoache, 1994). Toddlers (24- and 30-month-olds) were given a problem to solve that required the use of information from video: they watched a "live" video presentation of a toy being hidden in the room next door; then they were asked to retrieve the toy. To find it, children needed to use what they had learned from the video to form an inference about a real situation (the location of the toy in the next room).

During an orientation to the task, we attempted to demonstrate how live video relates to ongoing reality (Troseth & DeLoache, 1998). The children saw themselves, their parents, the researcher, the furniture in the room (future hiding places), and the toy on the video screen, while the researcher pointed out the correspondence of the images to the real objects. Most children loved seeing themselves "on TV," and many engaged in interacting with their own video image.

Next, the children were seated in front of the video monitor in an adjoining control room. As they watched, the assistant walked out, closed the door to the next room, appeared on the video screen, hid the toy, and returned. The researcher directed children's attention to the events appearing on the monitor, narrating the assistant's behavior without labeling the hiding place. Finally, the children were asked to go find the toy in the room.

The 30-month-old children usually knew where to search for the toy, retrieving it on 79% of the 4 trials (searching first in the right location was counted as correct). In contrast, the 24-month-olds frequently did not use what they saw on the video screen to guide their search, finding the toy only 44% of the time (Figure 2, *Standard Video*). Only a few younger children were highly successful. The younger children's poor performance has been replicated by us (Troseth, 2003b; Troseth & DeLoache, 1998, experiment 3) and independently by other researchers using very similar search tasks (Deocampo & Hudson, 2005; Schmitt & Anderson, 2002). The same age difference was found when toddlers were asked to use photographs and line drawings as a source of information (DeLoache, 1987; DeLoache & Burns, 1994). Thus, young toddlers do not easily get information from a depiction and apply it to a real problem-solving situation.

Why did 24-month-olds not use the video (or picture) to succeed at the search task? This simple task requires children to use video in a way they probably have never done before. To find the toy, children must take what they see on a television

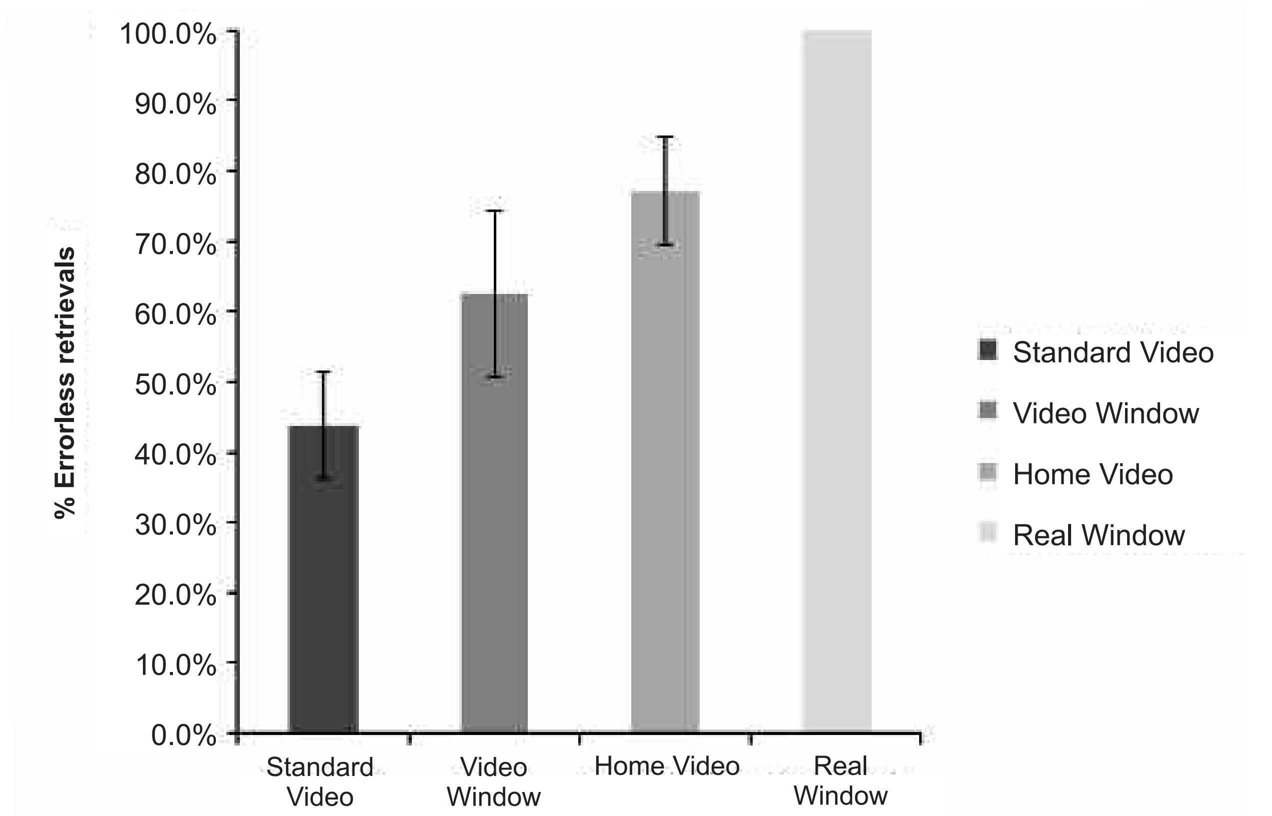

Fig. 2: Percentage of errorless retrievals achieved by 24-month-olds who searched for a toy in four information conditions: live video of hiding events (Standard Video); live video visible through a window, with monitor hidden (Video Window); live video experience at home before search task (Home Video); direct view through a window (Real Window). Vertical lines depict standard errors of the means.

screen as a source of information *about present reality*. They need to mentally represent a real, current situation (the location of the toy in the room) based on what they see on TV. Because this situation may be outside their previous experience, we gave 24-month-olds some additional training to figure out the connection.

One study was designed to emphasize the correspondence between video and reality. During 4 training trials, the door to the hiding room was left open so that children (in the adjoining control room) could watch the assistant hide the toy in the room directly through the doorway and on the video monitor at the same time. The researcher directed the children's attention to the two views of the hiding event, and then stood in the doorway to momentarily block their view of the room before sending them in to find the toy. On the 4 training trials, when they could directly watch the hiding, the children almost always found the toy (91% correct). Immediately after, the children participated in 4 standard trials with the door closed so that the only source of information was video. Now children's mean level of retrievals was as low (41%) as that of 24-month-olds who did not receive training (Troseth, 2003a, experiment 1). Obviously, the connection between video and the hiding event was not simple to learn.

Potential sources of difficulty

Children's failure to use information from video did not appear to result from poor memory, lack of motivation to search, or the inability to keep from returning to the previous location: The same children had no difficulty finding the toy when the door was open and they could watch directly as it was hidden. In another study, 24-month-olds watched the hiding of the toy through a *window* the size of the TV screen instead of on video (Troseth & DeLoache, 1998, experiment 2). The children who watched through the window *always* retrieved the toy—100% correct performance (Figure 2—*Real Window*). Thus, without the need to use video, they had excellent memories for the location of the hidden toy and did not perseverate when searching. Deocampo (2004) reported similar results in toddlers' solutions to means-end problems presented through a window and on video.

Additionally, young children's problems with video do not seem to come from difficulty interpreting 2-dimensional images. As described earlier, young infants behave toward video much as they would toward real objects and events, smiling at video images of people, attempting to grasp interesting toys, displaying fear toward scary masks, and imitating one-step actions on video (Diener *et al*., 2008; Meltzoff, 1988). A video presentation helps young children remember behaviors they learned weeks before. Hudson and Sheffield (1999) taught 18- and 24-month-old children 8 novel actions (e.g., pressing a toy bear's paw to make it talk), and then brought them back to the lab after a 10- to 16-week delay. The children were shown a video of a preschool child carrying out the actions they had learned previously. When they were tested the next day, they re-enacted the behaviors at a significantly higher rate than children did who had not received the video reminder. For all of these reasons, it appears likely that our video presentation is meaningful to our 24-month-old participants.

However, Evans Schmidt, Crawley-Davis, and Anderson (2007) voiced a specific concern: whether toddlers had difficulty interpreting a 2-dimensional image of a complex, 3-dimensional space. Perhaps children's problem with video (and pictures) in the search task is that a depiction on a flat surface does not allow them to reconstruct the spatial relations between objects in the room in order to search effectively. To test this account, Evans and her colleagues presented 24-month-old children with a *verbal* cue rather than a complex pictorial one. Children did not see the researcher on video hide a toy in the room; instead, she appeared on camera against a neutral background and simply *told* children where the toy was hidden. In another condition, the researcher stood right in front of children while giving the verbal information. Although this task did not require that 24-month-olds make sense of a complex array of spatial relations from video, they still did not use video-presented information to find the toy (only 20% correct). Children who directly saw and heard the researcher were much more successful (64%). Using Evans Schmidt *et al*.'s procedure, we found the same results (Troseth, Saylor, & Archer, 2006). Two-year-old children apparently do not evaluate verbal cues from video as equivalent to cues they hear directly. Therefore, toddlers' core problem with video does not relate to the difference between 2-D and 3-D stimuli, per se.

Representing symbolic relations

Given that 24-month-old children's difficulties in video tasks do not appear to stem from poor memory, lack of motivation, or problems getting meaning from a scene on video, we think their problem arises from the need for dual representation (DeLoache, 1987; 2000; DeLoache, Miller, & Rosengren, 1997). To retrieve a hidden object using information from video, children must mentally represent both the event "on TV" and the real event it stands for. In other words, they must recognize the symbolic relation between an image on a television screen and reality. Based on what they see on the video monitor, they must construct a mental model of the real event happening behind the closed door to the room, and use this representation to guide their search. On subsequent trials, they must update their mental representation of the current situation in the room using information from video, rather than relying on an outdated memory (the location of the toy on the previous trial). We think the 24-month-olds' problems in the object-retrieval task are attributable in large part to difficulty in achieving dual representation. Children watch and interpret the video event, but fail to relate it to the real event.

To test this claim, we attempted to remove the need for dual representation by convincing children that they were watching hiding events directly through a window (when they were actually watching a video) (Troseth & DeLoache, 1998, experiment 3). If children did not realize they were watching video, the task should be easier; they would not need to represent the "stands for" relation between video and the actual event; they would only need to mentally represent an event visible through a window. The logic follows that in a study of preschoolers' understanding of a scale model, in which a "shrinking machine" eliminated the need for children to represent a symbolic relation (DeLoache *et al*., 1997).

The key to the *video window* study was that the child never saw the video camera or monitor. After introducing the child to the room in which the toy would be hidden, the researcher took the child to the control room to "watch through the window" as the assistant hid the toy. Everything was as similar as possible to the procedure of the study in which children watched the hiding events directly through a window (except that the hiding event visible in the window was actually a video image). Behind the scenes, feverish activity produced this apparently seamless display: once the child left the room, the assistant rolled a cart containing the monitor and video camera out of hiding and positioned it in front of the window (a curtain over the window was then opened). The video screen, but not the rest of the monitor, was visible through the window. After the child watched the hiding event, the experimenter closed the curtain, and the assistant removed the cart before opening the door and inviting the child to search for the toy. This sequence was repeated for each trial.

The children were watching a flat, 2-dimensional video image, as they were in the other studies, but this time they were told they were watching through a window. Perceptually, the image was the same in both cases, but all of the typical contextual cues (e.g., the surrounding plastic case, buttons, and display lights of the TV) were obscured by the window frame as well as by the verbal suggestions. Nevertheless, if the children noticed the flatness cues, they still might mark the event as "on TV" despite our statement that this was a window.

The performance of a control group of children who saw the monitor and knew they were watching video was as inaccurate as in the original study (41%; only 3 of 16 children were correct on every trial). When the source of the information was obscured, however, performance was more accurate (63%), and significantly more children (9 of 16) were always correct. The results of this study thus support the dual representation hypothesis: More children used information from video when they did not need to mentally represent the symbolic relation between the video image and the actual event.

Experience with video

Children's prior exposure to television may explain why they fail to use information if they know it comes from video, since TV images usually are not immediately relevant to the world beyond the edge of the screen (Ittelson, 1996, p. 173). Most television programs depict people and events the child has never encountered in real life. The people on video may look as if they are talking to viewers, but they cannot respond if children attempt to talk to them. Furthermore, children's TV shows are often pure fantasy—cartoons showing violations of physical and biological principles, with people flying through the air and animals talking (Troseth, 2003b).

Given this experience, it would not be surprising if young viewers concluded that events on TV are separate from real life. Toddlers have learned that they cannot really grab a toy from a commercial or pat the kitty in a video. As they try to figure out the appropriate response to this strange, real-looking kind of object that is not really there, children may use the concept "*on TV*" to mark such entities as separate from their ongoing experience (Troseth *et al*., 2004). Until they develop a solid understanding that video images sometimes are *representations* of real events, toddlers' concept "on TV" may lead them to discount the relevance of video to a real problem they are trying to solve.

In a recent imitation study, we found suggestive evidence that toddlers' learning was affected by their prior experience watching TV. We used Barr and Hayne's (1999) imitation task and replicas of their original stimuli with 24-month-olds. Children who saw the video demonstration on their familiar home television (i.e., where they usually watched cartoons) produced only half the imitative behaviors of children who watched the same video on an unfamiliar monitor in the lab (Strouse & Troseth, 2008). However, children who saw a live demonstration at their home or at the lab imitated at the same high rate. Watching the demonstration in their typical TV-viewing context apparently made it more difficult for toddlers to remember and reproduce the modeled events.

One kind of experience that might clarify the connection between video and reality is *live video of children themselves*. Previous research suggests that the relation between a live video image and children's own movements may be central to self-recognition (e.g., Bahrick & Watson, 1985; Lewis & Brooks-Gunn, 1979; Povinelli, Landau, & Perilloux, 1996). Contingency between their behavior and what they see on the monitor also may convince children that events on a TV screen may relate to the real world. However, because children's self-recognition from live video lags behind their self-recognition in mirrors until their third birthday (Suddendorf, Simcock, & Nielsen, 2007), younger children may need substantial experience to learn the connection between their own image and current reality.

To determine the impact of live video experience, I had parents connect their video camera to the family television, and children saw themselves and their families (parents, siblings, pets) "live" on TV for 2 weeks (Troseth, 2003b). During five 10-minute sessions, their every movement and the consequences of their actions (e.g., building and knocking down a tower of blocks) were pictured on the screen. When they came to the lab, 24-month-old children with this experience used video to find the hidden toy; in fact, their correct searching (77% correct—Figure 2, *Home Video*) matched that of 30-month-olds in the original studies. The children also performed impressively on a transfer task with still pictures: after the experimenter pointed to a photograph of the hiding place, the children found the toy 60% of the time—much more often than 24-month-olds did in earlier picture research (DeLoache & Burns, 1994). A control group who did not get the live video experience was inaccurate on both tasks (video: 23% correct; pictures: 15%). Thus, children's prior experience affected their use of video for information.

In a correlational study of 120 toddlers, after controlling for child vocabulary and parent education and income, we found the same relation between children's everyday symbolic experiences (with live video, drawing, and pretending to write) and their success in using video and pictures for information (Troseth, Casey, Lawver, Walker, & Cole, 2007). Both experimental and correlational studies therefore suggest a connection between symbolic experience and children's understanding and use of representational media such as video.

With age, children need less experience to figure out the novel symbol-referent relation in the object retrieval task. After only a 5-minute orientation to live video, 30-month-olds readily recognized that a video image could inform them about the real events (Troseth & DeLoache, 1998). Several factors may be involved in this age-related advance in symbol use, including greater experience with a wide variety of symbolic objects, advancing language ability that allows children to grasp other people's symbolic intentions (c.f., Tomasello, 1999), and increased working memory and representational capacity supporting dual representation (DeLoache, 2002; DeLoache, Simcock, & Marzolf, 2004). Nevertheless, older children continue to have difficulty learning from video when the task is especially complicated (McGuigan, Whiten, Flynn, & Horner, 2007) or involves conflicting information (Povinelli, Landau, &

Perilloux, 1996; Zelazo, Sommerville, & Nichols, 1999). For instance, 5- to 7-year-olds produced less advanced solutions to balance scale problems when they saw the problems on video first compared to when they saw real problems first (Kerkman, Pinon, Wright, & Huston, 1996). Even beyond the toddler years, children do not always learn efficiently from video.

Mastering the conventions of video

After beginning to understand the relation between video and what it stands for, children still need to master a set of conventions comprising the “grammar” of video (Van Evra, 1990). As word order and morphology convey meaning in written language, a set of "formal features" conveys relational information and point of view in video (Wright & Huston, 1981; 1983). For instance, *zooms* show how a detail fits into its surrounding context, and *cuts* convey a change of perspective on a scene. “Symbolic conventions like these, taken together, form a code the viewer must know in order to comprehend what happens on the screen” (Greenfield, 1984, p. 10).

When children first encounter the code of video formal features, there are many opportunities for misunderstanding. Children must learn that a close-up does not indicate that a depicted object (e.g., an insect) is huge. A difficult concept for preschool children is that instant replay does *not* indicate the repetition of an action (Rice, Huston, & Wright, 1986). Processing formal features takes cognitive resources, leaving the novice viewer few resources to direct toward understanding the contents of a video.

Substantial evidence indicates that during the preschool years, children begin to figure out the code of formal features and to benefit from information presented in educational programs such as *Sesame Street* (e.g. Anderson, Bryant, Wilder, Santomero, Williams, & Crawley, 2000; Anderson, Huston, Schmitt, Linebarger, & Wright, 2001; Crawley, Anderson, Wilder, Williams, & Santomero, 1999; Mielke, 2001; Rice, Huston, Truglio, & Wright, 1990; Rice & Woodsmall, 1988; Wright *et al*., 2001; Zill, 2001). By the time they are five years old, children differentiate news stories (e.g., the wedding of Prince Charles and Diana) from dramas (e.g., the fictional *Royal Wedding*) using subtle formal cues that characterize the two genres (such as the speech disfluencies of unseen narrators in documentary news stories, and close-ups of conversations and music in dramas—Wright *et al*., 1994).

Video games

Young children's exposure to screen media now includes a substantial amount of time with video games. Many video games for young children include educational content as well as a challenge/reward system aimed at increasing engagement time (Gee, 2005). Virtually all include contingent features in which children's actions produce on-screen effects (thus bearing some similarity to the contingency present in the "live home video" described above -Troseth, 2003). An important area of study of video games will be the ability of children to transfer knowledge learned in the games to solve real-world problems.

A number of studies indicate that commercial video games for youth and adults can have positive effects on cognitive functioning, improving spatial ability (Subrahmanyam & Greenfield, 1994), increasing visual attention capacity (Green & Bavelier, 2003; Feng, Spence, & Pratt, 2007), and promoting faster visual stimulus response (Castel, Pratt, & Drummond, 2005). Games and simulations are being used for adult education (e.g., foreign language learning—Johnson, 2007). Video games also have been successfully used to teach children health care knowledge and skills (e.g., anti-smoking information and management of juvenile diabetes and asthma—Brown, Lieberman, Gemeny, Fan, Wilson, & Pasta, 1997; Lieberman, 2001). State support has been given to place video games promoting physical movement (such as *Wii*) in physical education classes (Schiesel, 2007). To date, although some educational video games have been commercially successful (e.g., *Big Brain Academy Wii Degree*) or have become part of official school curricula, there have been many barriers to the adoption of educational video games despite their promise as teaching aids (Gee, 2005).

Conclusion

Across early childhood, there are age -and experience- related changes in children's response to video. Young infants may learn from video by responding to an image as if it was real; they may represent the contents of the video without holding in mind its status as a 2-dimensional image (as when babies try to interact with people on a video or grasp at pictured objects). In contrast, older infants and toddlers seem to distinguish video as "not real"; they may notice contradictions between their growing world knowledge and the contents of fantasy programming, as well as the failure of people on video to be responsive to them. This awareness may temporarily lessen video's usefulness as a source of information for toddlers, as shown by the “video deficit” pattern in research results with this age group (Anderson & Pempek, 2005). Thus, children’s early conceptual representation of video may emphasize its *difference* from reality.

Nevertheless, toddlers *can* represent the relation between video and real events when they receive clear evidence of the connection, such as watching themselves on “live” video. When young children solve search tasks by choosing current information from video over outdated information from real life, they show that they have achieved “dual representation" (DeLoache, 2000) —simultaneously holding in mind the symbolic object itself (the video image) and the real event it stands for. Even without special training, merely from being exposed to a variety of symbolic media, children begin to augment their learning from direct experience by learning from video. A large body of research on the lasting educational benefits of exposure to *Sesame Street* and other programs indicates that, in the long run, high-quality educational video has a positive impact on cognitive development.

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