ATTENDING TO ACTION AT YOUR OWN PACE:

BENEFITS FOR KNOWLEDGE ACQUISITION?

by

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DISSERTATION ABSTRACT

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Past research has established that children typically learn better from live demonstrations than from 2-dimensional sources of information like video. The current dissertation investigated the efficacy of a new form of 2-dimensional learning medium, specifically the self-paced slideshow, where children advance through slides of an unfolding action sequence at their own pace. The primary purpose of this dissertation was to test whether the "video deficit effect" extends to the self-paced slideshow. In Experiment 1, children saw demonstrations of novel event sequences either live, via a video, or by advancing through a self-paced slideshow. They were then tested on their ability to perform the sequences, as well as their verbal memory for the action. Individual difference measures were also collected to provide some insight into how children's inhibitory control, theory of mind skills, and verbal ability related to their performance. Findings suggest that all children showed learning, in that children across the three learning media outperformed their peers in a no demonstration control group. In line with past work, children in the live condition outperformed those in the video and self-paced slideshow conditions at reproducing the target actions. However, children's memory did not differ across conditions.

To further explore the self-paced slideshow, Experiment 2 directly compared learning from the self-paced slideshow to learning from a video. Two alterations were made to the slideshow: the method of extracting slides was altered to create a more natural flow of action, and the content of the slides was altered to help children focus more on the object than the person. Children's performance differed little between conditions, with the exception of children reproducing fewer actions in the slideshow condition on two (of four) toys.

Ultimately, this dissertation documented that the video deficit effect extends to the self-paced slideshow: live demonstration produces superior learning for children. Future work should investigate at what age the self-paced slideshow might become a useful learning medium as well as how to enhance children's learning from 2D sources given the increasing role that they play in daily life.

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For my grandfather. That’s just ducky.

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CHAPTER I

INTRODUCTION

Children are phenomenal learners. During the first years of life, children make leaps and bounds in their understanding of the world around them. They readily learn language and how to communicate with others. They also learn about the human mind, and that other people have specific intentions, beliefs, and desires. They learn the functions of endless objects around them, and seek out objects with new and interesting uses. But how do children learn? What sources do they draw upon? Undoubtedly, much of the knowledge children acquire in these early years is gained without explicit instruction. Some years ago, Piaget (1954) reported on the importance of sensorimotor experience in childhood. By moving around their environment, and touching and manipulating items in their paths, children learn about new objects. However, given children's general naïvete, sensorimotor experience on its own is clearly not enough to equip children with all the necessary tools to understand their environment and the world around them. Thus, how else do children learn?

Children take advantage of a variety of learning media in their environment, both live sources of information (i.e. humans) as well as 2-dimensional sources of information (i.e. videos or computers). A distinguishing feature of human cognition is our ability to learn from others (Tomasello, Kruger, & Ratner, 1993). Even in the first year of life, infants begin to engage in joint attention with others (Tomasello, 1999) and read others' social cues with increasing ease (Baldwin & Moses, 2001). By the third year, children are becoming more adept conversational partners (Chaney, 1992). Ultimately, by at least as early as 30-36 months of age (Bloom, 2000; Strauss & Ziv, 2001), children understand that others are repositories of knowledge, and that they can take advantage of that knowledge in order to learn new information.

In addition to seeking out other humans, children also readily capitalize upon 2-dimensional sources of information. Research has shown that children are capable of learning information from videos (Barr, 2010; O'Doherty et al., 2011; Strouse & Troseth, 2008) and computers (Boucheix & Guigard, 2005; Calvert, Strong, & Gallagher, 2005). However, the literature has established that children tend to retain more information when learning from a live person than from a 2-dimensional source (Hayne, Herbert, & Simcock, 2003; Kuhl, Tsao, & Liu, 2003). Why might this be? Prior work has hypothesized that 2-dimensional information is perceptually impoverished (Hayne, 1999). Research has also established that young children have trouble transferring 2-dimensional information to the real world, perhaps due to a lack of representational flexibility (Hayne, 2009) and undeveloped symbolic reasoning skills (DeLoache, 1991). Research has argued that this "video deficit effect" persists until around 5 years of age (Flynn & Whiten, 2008).

Thus, the question arises as to how we might improve learning from 2-dimensional sources in order to increase children's success at gleaning new information from that form of media. One possibility is to provide the child learner with control over the pace of the presentation. Research on video learning has supported that adults (Mayer & Chandler, 2001; Zhang, Zhou, Briggs, & Nunamaker, 2006) and adolescents (Boucheix & Guigard, 2005) retain more information when allowed to control the pace at which they advance through a presentation when compared to watching a presentation at a set pace. Another possibility is to present the information in a form that helps children break down the information into meaningful units. Research has supported that children's ability to meaningfully segment action is positively related to their memory for that action (Meyer, Baldwin, & Sage, 2011). In this prior work, children advanced through a self-paced slideshow of an unfolding action sequence while a computer recorded how long they looked to each slide. Children's looking times reflected their ability to recognize the completion of goals and organize the information hierarchically in terms of the underlying goal structure. A primary goal of the current dissertation is to investigate the self-paced slideshow as a learning medium for children. Given that it has been shown to elicit meaningful segmentation in children and it gives children control over the pace of their learning, the self-paced slideshow seems ripe for further exploration. In particular, this dissertation will explore whether the video deficit effect extends to the self-paced slideshow.

This introduction will begin by outlining what we know about children's learning from other humans. I will argue that such social interactions often put children into a specific mindset for learning, referred to as the "pedagogical learning stance." I will then review the literature on learning from video sources, and circumstances in which this is or is not equivalent to learning from a live source. Next, I will discuss some recent work regarding learning from interactive computer presentations in adulthood, and then launch into a discussion of the use of interactive computer presentations in childhood and why the self-paced slideshow is worthy of the current investigation. I will end by outlining the specific research questions addressed in this dissertation.

Studies of Children's Learning from Others

Numerous theorists (Baldwin & Moses, 1996; Gergely & Csibra, 2005; 2006; Rogoff, 1990; 1991; 2003) have emphasized the critical importance of social interactions for learning. In particular, Vygtosky (1978) discussed the critical importance of social learning many years ago, and Tomasello (1999) has also described its role in cultural learning and link to many human achievements. Similarly, Harris (2002; Harris & Koenig, 2006) has asserted that children learn about many aspects of the world via the testimony of others, and children even have a dependence on testimony for learning about certain topics, such as unobservable scientific and religious concepts. Young children seem to have a robust bias to trust testimony, even if this information conflicts with other information they have encountered (Jaswal, 2010).

For the sake of this dissertation, social sources can be conceptualized as learning from live interaction or observation of another human, while non-social sources involve via trial and error or direct exploration of the world without reference to actions observed in others. Social sources bring something unique to the table that cannot necessarily be provided by non-social sources – namely, certain cues (e.g., eye contact or pointing) that help children determine what is relevant for learning. When children are left to their own actions or are merely observing some object, they do not necessarily have access to these cues that help hone their attention to what is relevant or important in their environment.

There is a wealth of research showcasing the privileged status of social information in infants' learning system. One striking example of this has recently been documented in the domain of phonological learning. Kuhl et al. (2003) found that language input provided in a rich social context (live, one-on-one, infant-appropriate interaction) enabled English-learning 9-month-old infants to retain sensitivity to a non-native (Mandarin) phonetic distinction that they would be expected to lose in the absence of Mandarin exposure. Interestingly, precisely the same Mandarin input presented non-socially (in either video or audio form) did not support infants' retention of Mandarin phonetic discrimination. Despite the fact that they heard a human voice (audio condition) or even saw a 2-dimensional image of a human speaker accompanied by a voice (video condition), this was not adequate in enabling them to retain the phonetic discrimination. Kuhl (2007; 2010) has referred to infants' sensitivity to social input, and the corresponding necessity of social interactions for learning, as the "social gating hypothesis."

Findings similar to Kuhl's work have also emerged in other areas of language learning, such as in the ability to learn words. There is an expansive literature demonstrating that infants' skill at capitalizing upon social cues is part of the explanation for how they develop word associations with such ease (Akhtar & Tomasello, 2000; Baldwin, 2000). Infants actively monitor cues of the speaker – e.g., gaze direction and gestures – to guide their inferences about word meaning. For instance, Baldwin (1991; 1993) noted that infants as young as 16 months would resist pairing a novel label with an object they were attending to because they subsequently noticed that the speaker (as shown by gaze, body posture, and voice direction) was directing the label to a different object. In further work, Baldwin and colleagues (1996) noted that infants did not form word-object associations in the absence of social cues. Infants heard a novel word while looking at a novel object either in the presence of social cues (speaker next to the infant and gazing in the infant's direction) or in the absence of social cues (speaker hid behind a screen and thus social cues were unavailable). These social cues, and particularly the cues to referential intent, were highly beneficial to infants' word learning, providing further support for the social gating hypothesis.

In related word learning work, infants appear to perceive social human agents differently from other sources of input in terms of trustworthiness. Koenig and Echols (2003) had 16-month-old infants listen to correct and incorrect object labels from a talking human agent, audio speaker, silent human agent next to an audio speaker, or a backward facing human. Infants were only surprised to hear the talking human agent falsely label an object, suggesting that infants are developing a conception of humans as truthful communicators and are surprised when that is not the case. Koenig and Harris (2005) also found that older children are quite good at determining when to trust a social source. In their work, children displayed trust in a knowledgeable over an ignorant speaker, as revealed by the speaker's correct or incorrect labeling of an object, and sought out that knowledgeable speaker for future information. An abundance of recent work with preschoolers has documented that children increasingly acknowledge some informants as more trustworthy than others based on the certainty and accuracy of their testimony, and will seek out reliable over unreliable informants (Clement, Koenig, & Harris, 2004; Jaswal & Malone, 2007; Koenig, Clement, & Harris, 2004; Pasquini, Corriveau, Koenig, & Harris, 2007). Thus, children appear to place their trust in other humans. While this element of trust may be present in children's relationships with live social others, it may not in their interactions with 2-dimensional media.

The preceding work all stemmed from the domain of language learning, but there is evidence for the social gating hypothesis from other domains, such as children's learning about objects (Moses, Baldwin, Rosicky, & Tidball, 2001) and their learning about causal relations (Sage & Baldwin, 2011). Thus far, I have conceptualized social gating in very broad terms, but social gating is a complex phenomenon with various branches. To highlight just one of these branches, I will now consider one specific form of social gating that has received recent attention in the literature – pedagogy.

Gergely and Csibra (2005) have suggest that a social context induces a specific attentional and interpretive attitude in children – the pedagogical learning stance – that assists children in identifying the parts of a motion stream that are new and relevant. In this manner, pedagogy is a specific mechanism for knowledgeable adults to pass on cultural knowledge to young naïve learners. Among other things, pedagogical signals (like gaze shifting or referential speech) are thought to help children disambiguate that the subsequent actions are intended to be communicative (Csibra & Gergely, 2009; Gergely, Egyed, & Kiraly, 2007). Gergely and Csibra hypothesize that humans are naturally inclined to use and manifest their knowledge for the benefit of naïve learners, and naïve learners in turn are naturally motivated to seek out and attend to such information in their environment.

Furthermore, the research has shown that pedagogy seems to emerge spontaneously in adults' interactions with infants, and is apparent in adults' speech and movements. For example, Brand, Baldwin, and Ashburn (2002) found that mothers spontaneously engage in motionese with infants, or a specialized form of action involving increased interactiveness, enthusiasm, proximity, range of motion, repetitiveness, and simplicity when compared to adult-directed action. These modifications capture infants' attention and highlight structure within the motion stream, producing benefits for infants' learning (Koterba & Iverson, 2009).

Looking to the infancy research, we see that infants indeed respond to a range of pedagogical cues, at least if we define such cues broadly in terms of social signals that adults employ in interactions with infants. Newborns prefer faces when individuals are looking directly at them relative to faces when individuals are not making eye contact (Farroni, Csibra, Simion, & Johnson, 2002). Infants shift attention if they can see a change in the adult's line of regard (Farroni, Mansfield, Lai, & Johnson, 2003). Pointing is also helpful in directing infants' attention to the appropriate location; infants begin following pointing gestures by roughly 11-12 months of age (Woodward & Guajardo, 2002). Infant-directed speech or "motherese" captures infants' attention because of its upbeat intonation and exaggeration (Fernald, 1985; Fernald & Mazzie, 1991). As children age, particular types of language, such as explanations or questions, might take the place of infant-directed intonation in indicating pedagogical intent. Recent work from our lab (Sage & Baldwin, under review) has shed some light on the use of pedagogical cues in preschoolers. Three and four-year-old children were observed in natural play activities with their primary caregivers. We noted that parents frequently capitalized upon such cues as pointing, demonstrating, suggestion-making, and referential speech when engaging with their children. Parents did not capitalize much on the cues of eye contact and name referral, probably because 3- and 4-year-olds are already quite fluent in making and receiving conversational bids. Overt eye gaze and name referral likely wane in their utility as pedagogical cues as children become older and more experienced.

Other literature has also addressed pedagogical learning in the preschool age range. For instance, Rhodes, Gelman, and Brickman (2010) studied pedagogy in terms of how it affected children's attention to sample composition, or the creation of diverse samples to represent a category of interest. In their work, 5-year-old children successfully attended to sample composition and made inferences about biological properties only if the samples were presented pedagogically. This suggests that children interpret information differently depending on the pedagogical context of the situation. Pedagogy also seems to arise spontaneously in more informal settings, such as joint play between parent and child. Relevant to this possibility, Bonawitz et al. (2011) documented that preschoolers are sensitive to pedagogy in a play context. In their work, pedagogy focused children's attention to particular functions of a toy while also restricting children's exploration during play. These two studies provide support that pedagogical cues affect learning in preschool-aged children, potentially by helping to hone their attention to certain aspects of objects.

Recall that pedagogy is a specific form of social gating. It may be unique in that some of its benefits for learning may rely on a learner identifying the teachers' instructional intent, and thus engaging the "pedagogical learning stance." Social gating more generally may not require quite the same level of sophistication on the learner's part, such as when a learner responds to a social situation with enhanced attention or focus. Regardless of whether we are talking about social gating more generally, or pedagogy more specifically, the take-away message is that children orient to information couched in a social context. But why is this the case? In other words, what are the mechanisms behind social input benefitting children's learning?

One potential option is that social input merely enhances children's attention or arousal. Kuhl et al. (2003) support this, reporting that infants attended more to the live speaker than to the matched video in their study, and that infants showed increased arousal to the live actor; specifically, they watched the door for her arrival and acted excited. Perhaps increased attention/arousal led infants to encode more and/or higher-quality information. However, in my recent work in the domain of causal learning (Sage & Baldwin, 2011), attention was strikingly equivalent in terms of infants' attention to a social versus a non-social demonstration. Despite this equivalence of attention, infants in the social condition learned a causal sequence with higher success than their peers, suggesting that a more complex mechanism was at play behind the benefit of social input. This is not to say though that social input does not help children focus in on the particularly relevant portions of a motion stream. In support of this idea, we recently found that, despite equivalency of attention to a social versus non-social demonstration, infants in the social condition focused moreso on the causal structure of a tool-use event when compared to infants witnessing a non-social demonstration (Sage & Baldwin, 2012). We discovered this by allowing infants to advance through a slideshow displaying the causal sequence, and, though overall attention did not differ, infants' allocation of attention to the different slides in the sequence did show different patterns across the two conditions. Thus, though perhaps not an attentional boost per se, social cues might help direct children's attention to the most pertinent portions of an action sequence.

Another potential mechanism behind the benefit of a social context is that social partners provide communicative cues that foster learning, such as eye contact and pointing. They also provide a level of interactivity and contingency not necessarily possible in other forms of learning media. Such contingency and use of communicative cues might help children focus in on particularly relevant components of a motion stream. This option seems to point to children adopting a pedagogical learning stance when in a social context, which might prime them to attend to new and relevant information (Csibra & Gergely, 2009). Relevant to this possibility is that children also seem to make trust judgments when social others are present, but not when exposed to other sources of information (Koenig & Echols, 2003). This suggests that social beings might hold a privileged status in children's learning system.

Studies of Children's Learning from Video

As we saw in the prior section, children readily attend to information in a social context. It is no surprise that children learn from other humans; however, what are other sources of information that might help children learn? As mentioned briefly earlier, research has also sought to determine if video can be an effective learning medium (e.g., Kuhl et al., 2003). To this end, much research has pointed to a "video deficit effect" persisting until at least 3 years of age (e.g., Barr, 2010; Barr, Garcia, & Muentener, 2007; Barr & Hayne, 1999; Nielsen, Simcock, & Jenkins, 2008) and possibly even until 5 years of age (Flynn & Whiten, 2008; McGuigan, Whiten, Flynn, & Horner, 2007). This deficit refers to children's poor ability to transfer learning from television and still images to real-life situations in comparison to their skill at transferring learning from face-to-face interactions with others. In seminal work, McCall, Parke, and Kavanaugh (1977) found that 18-, 24-, and 36-month-old children would imitate from a television, but their performance was lower in comparison to a group of children exposed to a live person. However, the gap between live and video learning was beginning to close by 36 months.

More recent work comparing 3- to 5-year-old children has shown that three-year-old children still show video deficits in their reproduction of target actions, whereas 5-year-olds imitate quite well from video (McGuigan et al., 2007). The finding that the 5-year-old children learn well from the video could potentially be due to their increased age (e.g., more skilled at gleaning information from all types of sources) or an increase in their time in front of the television more generally (e.g. more years of experience with that form of media when compared to the 3-year-old children).

In other work, Hayne et al. (2003) found converging evidence that children before age three have challenges with imitating from television. Three- and 2½-year-old children watched an adult perform a series of actions either live or on videotape. The adult was positioned across from the child and modeled a 3-step sequence three times in succession without verbally describing the actions. The demonstration lasted 60 seconds. Children's reproduction of these actions was then assessed either immediately or after 24 hours. Across both age groups, children did successfully model both the live and videotaped adult. However, performance was significantly higher for children witnessing the live demonstration. The authors argue that the inferior performance after viewing a videotaped demonstration may reflect a "generalization decrement." In other words, the similarity between the presented 2D version of the object and the live 3D object presented to children may not be sufficient for them to reproduce the actions with high success. As children age, they might improve at recognizing the similarity between 2D images and 3D objects.

This video deficit effect is not only evident in the domain of object learning, but also in the domain of word learning. Roseberry, Hirsh-Pasek, Parish-Morris, and

Golinkoff (2009) investigated verb learning across three media types in 30- to 42-month-old children. Children saw either a video supported by live social interaction, just a single video, or a video supported by another video. The younger children only learned verbs from video with live social interaction accompanying it. However, as the children got older, they seemed to be able to learn across the video types. Thus, just as the video deficit effect seems to begin to diminish after about 3 years of age in the realm of object learning, the same can be said in the domain of language learning.

Barr (2010) points to numerous reasons why a video deficit exists in young children. She believes that demands on perceptual and symbolic processing contribute to the reduced ability to learn from television, as well as potential demands on memory and a lack of social contingency. To illustrate, Courage and Setliff (2009) reported that 2D information is processed more slowly and is more cognitively taxing than learning from a live person. DeLoache (1987; 1989) has long suggested that toddlers have a problem comprehending a symbol as both an object in itself (the toy) as well as a representation of another object (the depiction of a toy). Thus, children may not translate what they see in a video to actual imitation when presented with the object. It seems likely that, in order to learn from video, a child must appreciate how 2D and 3D stimuli are both similar and different and be able to respond accordingly (Troseth, Pierroutsakos, & DeLoache, 2004).

Other research has sought to determine ways in which video might incur successful learning equivalent to that of a live demonstration. Strouse and Troseth (2008) found equivalent learning from a live versus videotaped action sequence in 2-year-old children. In their demonstration, the adult drew the child’s attention (saying “Look at this!” while providing eye contact) and performed the action. The actor then repeated this for a total of three demonstrations per sequence, lasting for approximately 2 minutes. Children either viewed the demonstration live, an identical video demonstration, an identical video demonstration but filmed in a different location, or a shortened video demonstration with the portion of the video that including taking apart the toy deleted. Across the three videotapes, the authors found no differential effect on 2-year-old children's imitation of target actions. Nor did it differ from children's performance in the live condition. On the face of it, this seems in contrast with the previously reported findings of Hayne et al. (2003). However, we can note that the duration of the video was *twice* as long in the Strouse and Troseth study. In fact, Strouse and Troseth hypothesized that the duration of the video might be resulting in the boost in learning for the video demonstration relative to prior research. Thus, their second experiment shortened the demonstration to 1 minute – showing only a single demonstration to children either live or on video. Indeed, now children who witnessed the live demonstration imitated significantly more steps than children viewing the video. Thus, it appears that duration of the video matters, perhaps in terms of how many instances of the demonstration a child has the opportunity to view.

Several other studies suggest that giving a child experience with 2D media benefits their later learning from video. Troseth (2003) found that, if 2-year-old children watch themselves live on their home television for an hour, then they are three times as successful on a search task in the lab. Troseth, Casey, Lawver, Walker, and Cole (2007) also found that the strongest predictor of correct searching in the lab was children's experience with live video, and specifically experience with video of themselves. It seems plausible that children may not readily conclude that people on television are social partners. To this end, Schmidt, Crawley-Davis, and Anderson (2007) confirmed that children are more likely to follow directions given by a person in the same room than the same person on video. However, if given experience with a contingent video (e.g., the person says the child's name, plays a game with the child over a video stream, etc.), then the child readily uses the information provided by the person in the video (Troseth, Saylor, & Archer, 2006).

Furthermore, even younger children may be able to learn from video, but it may take significant engagement with the video. Werker, Cohen, Lloyd, Casasola, and Stager (1998) were curious when infants would be able to learn word-object pairings from video without any accompanying exposure to social cues. Before 14 months, children did not seem to be able to learn the word-object pairings. At 14 months, the infants seemed to learn the word-object pairings but only if the objects in the video were moving. Perhaps the movement of the objects facilitated attentional focus and allowed infants to learn the pairings. Successful learning from video is thus possible even in infancy.

To summarize, there is much research pointing to the benefits of learning from a live person over a video presentation (e.g., Hayne et al., 2003; Kuhl et al., 2003; McCall et al., 1977). However, making the duration of the video longer (Strouse & Troseth, 2008), giving the child experience with seeing themselves on video (Troseth et al., 2007), or giving the child a contingent experience via video (Troseth et al., 2006) can help increase children's learning from video and make it equivalent to their learning from a live person. With this knowledge of how video affects learning in mind, I now turn to another form of 2-dimensional media: the computer. Since this form of media is much newer than that previously described, I will first discuss the literature with adults before launching into a discussion of interactive computer presentations with children.

Studies of Interactive Computer Presentations in Adulthood

Recent research with adults has investigated the use of interactive computer presentations, and how this affects the learning process. A variety of different methods have been taken to make a presentation interactive for adult users. Zhang et al. (2006) studied four different learning settings in college students: the traditional classroom environment, an e-learning environment on the computer with an interactive video, a non-interactive video, or no video. By their definition, interactive video referred to "the use of computer systems to allow proactive and random access to video content based on queries or search content" (p. 17). In their study, college students were taught about Internet search engines as part of an Internet technology unit in a college course. The interactive video on the computer involved being able to select small video clips to view, and thus navigating oneself through the learning process. Findings pointed to learning effectiveness being a function of interactivity. Students with the interactive video showed significantly better learning, as well as reported higher learner satisfaction, than students in the other settings. The researchers believed that interactivity provided more flexibility in meeting individual needs and thus provided a more tailored learning experience.

Other researchers have speculated on why an e-learning (or computerized learning) environment may be beneficial for adults (Kumar, Kumar, & Basu, 2001). This type of learning is thought to foster self-directed and self-paced learning; in other words, it is very learner-centered as it gives adults control over their learning experience. It also allows unlimited access to the material; learners can spend as much time as they'd like reviewing the information presented in this manner.

The preceding study (Zhang et al., 2006) suggested that giving a computer presentation an interactive component (in their case, being able to self-select video clips to watch on the material via a computer program) enhances adults' learning. In further support of this, Schaffer and Hannafin (1986) reported many years ago that breaking videos into segments so that there are pauses between clips results in better memory for the material when compared to a continuous video stream. Perhaps unsurprisingly, the more interactive the video in their experiment, the longer it took the students to complete their viewing, and thus the slower their acquisition rate of knowledge. Essentially, the more interactive videos allowed students to slow down their processing, which may have resulted in more successful learning of the information as they had more time to process and mindfully navigate the information. Thus, it seems as if two components of interactivity might be particularly helpful in enhancing the learning experience for adults: (1) the learner having a level of control over their own experience, and (2) the material being presented with pauses as opposed to a continuous flow of information. With these two characteristics in mind, I will now turn to a piece of research investigating the usefulness of slideshows in adults' learning, as this is particularly relevant to the current research.

Mayer and Chandler (2001) were curious how user interaction with a slideshow might affect learning outcomes. They hypothesized that being able to interact and control a slideshow (as opposed to just watching an animation advance on its own) might reduce the cognitive load placed on a user's working memory, thus enabling the learner to process information more efficiently. Conversely, if information was just presented all at once with no opportunity for pause, one's working memory might become over-tasked. For instance, users might have to divert all their processing abilities to simply taking in the information being presented, and they would have few resources left for actually organizing that information. However, if the presentation were presented piece-by-piece as a result of a learner controlling the speed of the presentation, perhaps the learner would have time to both absorb and organize the information. This is not unlike the work by Zhang et al. (2006) and Schaffer and Hannafin (1986), in the sense that the user had the chance to break down the information into smaller pieces during the initial presentation, thus making the presentation more interactive and more learner-centered than a presentation presented at a continuous pace in its entirety.

To investigate this possibility, Mayer and Chandler (2001) presented slideshows to undergraduate college students on the topic of lightning formation. All students watched two presentations. In one version, the students saw the whole presentation as one continuous show. In a second version, the students saw the presentation in parts by clicking a button at their desired pace to view a total of 16 segments of information. In Experiment 1, students saw either the whole version first followed by the segmented version or vice versa. The researchers hypothesized that segmented followed by whole presentation would be the more effective ordering, as this allows the learner to break down the material first before viewing the continuous stream. In Experiment 2, students saw either the whole version twice or the segmented version twice. The researchers hypothesized that viewing the whole version twice would be more cognitively taxing, and thus result in lower levels of learning than viewing the segmented version twice. In both experiments, students recalled an equivalent number of major ideas when asked to write down how lightning occurred (after all, they had all seen the same information twice). However, the segmented then whole presentation group in the first experiment and the group viewing the segmented version twice in the second experiment produced significantly more solutions on a transfer test than the other group in their respective experiment. This transfer test involved questions like “what does air temperature have to do with lightning?” The purpose of this transfer test was to tap into deeper knowledge, as the goal of the segmented video was to minimize cognitive load as a means of allowing learners to organize the information more coherently. In this manner, advancing through the 16 segments did seem to benefit students’ learning.

Numerous researchers provide evidence that giving the learner control over the pace of a presentation or providing information in meaningful segments is a useful strategy for reducing cognitive load and increasing learning (e.g., Mayer & Chandler 2001; Mayer & Moreno, 2003). Maintaining control over one’s own pace allows viewers to tailor a presentation to their unique needs and pause whenever they feel is necessary. By offering a segmented version of a presentation, learners are being shown discrete segments with meaningful pauses, rather than one continuous flow of action, which presumably allows them to more deeply process the information. But do these two viewing alterations – control and pauses at segment boundaries - always benefit learning?

Some existing research suggests that interactivity in a computer program might not always be a learning aid. For example, Moreno and Valdez (2005) also provided college students with information about the process of lightning formation. In their first experiment, college students learned about lightning formation from one of three types of computer programs. Group 1 saw a set of images illustrating the main steps of the lightning formation in pictures. Group 2 saw a set of images consisting of only words. Group 3 saw a set of images that included both pictures and words. In addition, half of students saw the sequence in the correct order while half of students had to re-organize the images to put them in the correct order; in other words, the latter group underwent a more interactive experience with the frames presented on the computer. Following their viewing of their assigned set of images, students had a similar retention and transfer task to that described in Mayer and Chandler (2001). Findings suggested: (1) students did better when exposed to two sources of information (e.g., both words and pictures in the image), and (2) self-organization was actually a detriment to students' learning.

Moreno and Valdez (2005) put forth two potential explanations for why interactivity (in the form of self-organization of the images) did not help students learn. First, students were constrained in organization time in Experiment 1, which could have been frustrating and thus hampered the learning process. Second, instant feedback was incorporated (e.g., "Correct!") upon students placing an image in the correct spot. This might have encouraged a trial-and-error approach rather than a more thoughtful approach. Thus, two additional experiments were conducted to determine why students performed worse in the original self-organization condition. Experiment 2 increased learners' level of control over the presentation in the sense that the time constraint was eliminated. Interestingly, whether the student or the computer controlled the time did not affect learning. In fact, to the surprise of the researchers, users went through the program more quickly when given self-control. In Experiment 3, the feedback component was put to the test. Students either got the same feedback as before or were simply asked to double-check their answers before submitting. In this case, students double-checking their answers showed better learning than students receiving feedback from the computer. This suggests that feedback is beneficial only when it promotes intentional processing; in other words, encouraging viewers to reconsider their options was more beneficial to the learning process than the computer simply confirming or disconfirming a choice. Taken together, this series of experiments suggests that having control over pace may not always be a benefit to learning, and that careful consideration needs to be given in terms of what type of feedback is provided to students. Methods that promote deeper processing (such as having to double check your own work) are likely to result in increased learning relative to methods that promote guess-and-check strategies.

At the end of their article, Moreno and Valdez (2005) suggest that the design considerations behind creating effective learning media might be especially pertinent when working with novice learners, as the novice learner may lack experience with elaborating information into deeper knowledge. In other words, while college students might be able to overcome certain design flaws in learning media and still glean some information from a presentation, younger children might have a more difficult time given their lack of experience with the “meaning making” process. With that in mind, I now turn to the use of interactive computer presentations in childhood.

Learning from Interactive Computer Presentations in Childhood

Recall that computer programs allowing learners to control the pace or see the information in separate pieces can offer benefits for adult learners over-and-above more continuous streams of information (Mayer & Chandler, 2001; Zhang et al., 2006), though we should also remind ourselves that interactivity does not guarantee superior learning

(Moreno & Valdez, 2005). Pacing a computer presentation and seeing it in pieces also seems useful for learning in adolescence. Hasler, Kersten, and Sweller (2007) presented 9- to 11-year-old children with one of 4 educational animations providing information on day and night: a system-controlled continuous animation, a learner-paced animation presented in set segments, a learner-paced animation controlled by stop and play buttons, or a narration-only presentation. All children then answered a series of questions. The two learner-paced groups (viewing either segments or controlling their pace) showed higher test performance than the other two groups on the more difficult questions, providing support that the opportunity to control one's pace may be beneficial to learning at this younger age.

Interestingly, even though we see this advantage of self-paced viewing in comparison to the continuous viewing, most children did not regularly use the stop/play buttons when given that option. One potential reason for this is that perhaps learners were unsure when to pause given their lack of knowledge about the material (i.e., children may not have been sure when it was important to stop). However, it seems likely that the child learners were constantly scanning the screen to search for a stopping point, which may have resulted in their superior learning despite essentially seeing a continuous animation stream. In a sense, it was as much the belief in one's own locus of control (e.g., children knew they could pause if they wanted) as the actual control that produced the learning benefit.

In a similar study with seventh and eighth graders, Boucheix and Guignard (2005) were curious about three rhythms of presentation: faster, slower, and self-controlled. Students received a multimedia lesson on how gears functioned. This lesson consisted of

19 slides. The computer controlled the fast and slow speed versions of the presentation. The self-paced version allowed the learner to control the pace of the presentation of slides by clicking the next button on the screen. Children could not go backwards through the slides. Findings showed that the type of slideshow did not affect children's immediate comprehension; they were equally likely to answer the same number of questions correct out of 15 questions immediately following their viewing of the show. However, students allowed to control their own pace improved more from a pre-test to a post-test focusing on relevant material explained in the slideshow than students in the fast or slow paced groups. The researchers also looked at how long students took to go through the lesson. The fast group was set at 100 seconds; the slow group was set at 250 seconds. The self-paced group actually took even longer to go through the lesson – averaging around 390 seconds. This suggests that they spent a longer amount of time processing and thinking about the information at-hand. The findings here with adolescents seem to be compatible with the findings presented earlier with adults in Mayer and Chandler (2001), demonstrating that learner control is one method of improving learning from computer presentations. Giving children control over the pace might make the learning experience more active (as they are clicking and controlling what is happening), as well as allowing the pace to suit the individual child (i.e. the child who learns quickly might click through faster while the child who learns more slowly might click more slowly).

The prior work was completed with adolescents, with the youngest participant being 9 years of age. What about the use of computers with even younger children? Preschool-aged children often have access to computers in the home, and are quite skilled at many aspects of computer use (Zevenbergen & Logan, 2008). One relevant study in this regard investigated how user control affected children's attention to and learning about a story presented on the computer. Calvert et al. (2005) presented 4- and 5-year-old children with a computerized storybook that had 13 pages to flip through. When the cursor was moved over different parts of each page, certain words or images appeared. Children either had control over the storybook, an adult had control, or the adult and child shared control by taking turns. Children saw the story a total of four times. Children who had control over the storybook maintained high levels of attention across all exposures to the story. However, in the adult and joint controlled conditions, children's attention declined as they went through the storybook more times. This suggested that they were losing interest as the study progressed, and that having control over the storybook facilitated both children's attention to and interest in the activity. In contrast to its effect on attention, the type of control children had over the storybook did not affect their memory, as measured by a comprehension test. One possibility for this is that all children saw the storybook presentation four times, which could have led to a ceiling effect on learning. In fact, it has been shown that repetition enhances learning in childhood (Crawley et al., 1999). It seems plausible that, if the children were to have only seen the storybook once, there might have been differential effects between conditions on memory.

Another set of questions concerns whether or not children are enjoying this type of activity and at what age children are capable of interacting with the computer. In a descriptive study addressing these issues, Liu (1996) reported that children adapt quickly to using the computer as a learning medium, and that having control over the program is a key aspect of keeping the child engaged. Specifically, she investigated computer use among 3- to 5-year-old children by showing them a computer program that taught the children about spatial relationships (which was part of their preschool curriculum). Prior to viewing the program, children were taught how to use the mouse and see the cursor on the screen. They were then allowed to navigate through a series of clips by using the mouse, after which they were asked questions and interviewed about their experience.

Numerous interesting findings emerged from this work. First, most children did not have prior experience with a mouse but readily learned how to use it and experienced no problems with its functionality. Only 1 of the 12 children seemed to have difficulty and required prompting by the experimenter. Liu also commented that clicking a mouse appeared to raise curiosity in the children, as well as lead to a sense of satisfaction after having "conquered" the mouse. Most of the children also smiled throughout the program, indicating that they were enjoying the activity. Children remained engaged by the program as well, and average time on the program ranged from 24 to 35 minutes. Children did, however, have difficulty learning words from the program. Thus, though children were capable of performing this activity and seemed to enjoy the program well enough to stay involved for around half an hour, the actual learning from the program was low. It is possible that children just thought it was a game (e.g., click here and something happens) as opposed to a learning opportunity. It seems less likely that the material was inappropriate, given that it was part of the typical preschool curriculum. However, another possibility is that truly novel information may not be best learned from a computer when children are left to their own devices; in other words, perhaps some adult guidance is necessary for understanding new concepts.

Given her findings, Liu (1996) concludes that children ages 3 and older are prepared to use interactive media on the computer, as they readily use the mouse and seem to enjoy the activity. One question that remains unanswered concerns what type of interactive computer program is optimal for facilitating learning in preschool-aged children. Based on the literature presented here on interactive computer presentations, it seems that important aspects to consider are: (1) letting the learner control the pace (e.g., Boucheix & Guignard, 2005; Zhang et al., 2006), (2) allowing pauses so that the learner does not just see one continuous flow of action (e.g., Mayer & Chandler, 2001; Zhang et al., 2006), and (3) making sure the material is developmentally appropriate (e.g., Liu, 1996). In an attempt to answer this question, I will investigate the effect of a new learning medium on children's learning: the self-paced slideshow. Such a slideshow would permit children to advance at their own pace through a series of slides depicting an unfolding action sequence. However, it is not a foregone conclusion that children will be able to control their pace as efficiently as adults. For one, children's executive function deficits relative to adults (e.g., Anderson, 2002) might mean that children, when given the opportunity to pace themselves, might move through the material so hurriedly that they do not give themselves the chance to properly process the content. However, children do seem fully capable of successfully using a computer mouse to navigate through computer programs (Liu, 1996), so this potential for self-paced viewing in childhood does seem worthy of further investigation. To better explain why the self-paced slideshow shows particular promise as a learning medium, I will now turn to the literature related specifically to the creation of this slideshow and why it might be beneficial for children.

Inspiration Behind the Self-Paced Slideshow

Humans readily draw intentional and causal inferences about others' behavior, often with little conscious effort and in spite of human behavior presenting a complex display of information to be processed. One component underlying adults' processing of dynamic action is segmentation, or identifying individual acts within the continuously flowing stream of behavior. When adults are asked to segment continuous action (such as a scene depicting a motorcycle being repaired), they display a high degree of consistency in the units they identify (Newtson, 1973; 1976) and such units often coincide with boundaries based on the actor's intentions (Baldwin & Baird, 2001). Interestingly, recent work has shown that even young infants have the ability to identify segments within dynamic intentional action (Baldwin, Baird, Saylor, & Clark, 2001; Hespos, Grossman, & Saylor, 2010; Saylor, Baldwin, Baird, & LaBounty, 2007). However, the primary methodology for measuring the segmentation of action in childhood is limited; most demonstrations of segmentation utilize a looking-time paradigm. While such findings suggest that an infant or child is sensitive to segmental structure, it provides little information regarding how their processing of segmental structure actively unfolds across time. A new methodology has recently emerged that might provide more nuanced information regarding how humans of all ages segment action. This method is of particular interest in the present context because it involves use of a self-paced slideshow.

To investigate how adult observers view familiar intentional action scenarios (like making a bed), Hard, Recchia, and Tversky (2011) measured adults' "dwell times" to both the segmental and hierarchical structure of an unfolding event sequence. In this work, the researchers created four digitized videos of familiar action sequences, and extracted still frames at a constant increment. Observers viewed these still frames in the format of a self-paced slideshow, where they had the chance to click through the frames at their own pace. A computer program simultaneously recorded their dwell times to each slide. The adults were subsequently asked to watch the videos and nominate meaningful junctures within the action sequences (called breakpoints, in line with Newtson's 1973 classic segmentation method). Analyses then investigated the relation between dwell-time scores and the segmentation judgments of the viewers. Results indicated that adults dwelt longest on slides corresponding with segment boundaries (e.g., a slide showing the initiation or completion of an action). Furthermore, adults did this in a hierarchical manner – they dwelt longest at coarse breakpoints (e.g., finishing making the bed), slightly less to intermediate (or medium-level) breakpoints (e.g., finishing putting the sheets on), and slightly less still to the fine breakpoints (e.g., finishing the tucking in of one sheet corner). Hard and colleagues interpreted these findings as demonstrating that adults view the transition from one segment to the next segment as a bridge in their conceptual understanding, and thus allocate more attention to them. The "bigger" the breakpoint, the more information-rich the slide, and the more attention it receives.

Given the ease of administering the dwell-time paradigm, we wondered if such a method could be used with children. In our initial work (Meyer et al., 2011), we had preschoolers pace themselves through a child-friendly slideshow (e.g., a woman waved, stacked a series of rings, nested a set of graduated cups, and placed two stuffed animals in a box before waving again). Similarly to Hard et al. (2011), we extracted slides from a digitized video of the event at a rate of one slide per second. Children were given some practice with the methodology, and were then asked to click through this slideshow with a computer mouse. Following this, children were asked a series of eight memory questions regarding the objects and actions they had witnessed in the slideshow. Again, as in Hard and colleagues' research, children dwelt longer on breakpoints in action, and dwell times increased as a function of breakpoint grain. Strikingly, children's memory accuracy was also related to their dwell-time patterns. Children with superior memory performance showed dwell-time patterns indicative of segmental and hierarchical structure, whereas dwell-time patterns were less systematic among children who displayed some inaccuracies in their memory. This seems to clarify that the dwell-time paradigm is tapping something psychologically real in children, as dwell-time effects relate to other aspects of their cognitive processing.

Interestingly, this paradigm is also readily usable with an infant population. With one small adjustment – infants tapping a touchscreen instead of using a mouse – we can measure segmentation in children as young as 6-8 months of age. Our initial study (Baldwin, Hard, Meyer, & Sage, in prep) investigated infants' dwell-time patterns to a slideshow depicting a woman stacking a series of graduated cups on top of each other. Instead of extracting slides from a digitized video at a consistent rate, we specifically selected still frames alternating between segment boundaries and mid-stream action. This meant that all possible breakpoints were shown to infants (unlike in prior slideshows, where some breakpoints were missed as a result of the consistent extraction rate). Our rationale for this change was that infants' slideshow needed to be brief (here, 18 slides) so as to not lose their attention. Despite this difference, infants dwelt longer on slides depicting breakpoints in action relative to mid-segment slides. This suggests that infants can indeed use the dwell-time procedure, and that the dwell-time paradigm has the potential to capture sensitivity to segmental structure across the ages. More recent work with the dwell-time paradigm has suggested that infants segment action in the same hierarchical fashion as their older counterparts (Sage, Ross, & Baldwin, 2012) and that a social context preceding a slideshow may enhance infants' ability to detect structure in action (Sage & Baldwin, 2012).

In response to this initial work with the dwell-time paradigm, I wondered if this method could be converted into a learning medium. In other words, might children be able to learn novel action sequences through a self-paced slideshow? The current research varies from the prior work in that the self-paced slideshow was previously utilized to provide insight into humans' processing of unfolding events as opposed to unveiling actual effects on learning in comparison to other forms of learning media. The self-paced slideshow utilized in this dissertation also varies from the interactive computer presentations discussed earlier in the introduction. The slideshow utilized by Mayer and Chandler (2001) contained slides informing the viewer about different aspects of lightning formation. Similar to other research presented earlier (e.g., Zhang et al., 2006), this allowed the viewer to control their pace and see the information in segments. However, these slides were not still frames extracted from an unfolding action sequence. Their slides contained related pieces of information, but did not represent just one unfolding event. The current self-paced slideshow is thus similar in that it gives the user control over pace (e.g., Liu, 1996; Mayer & Chandler, 2001; Zhang et al., 2006), but different in that the viewer is witnessing an event unfolding, frame-by-frame, in front of them.

The self-paced slideshow seemed particularly promising for two reasons. First, as I have mentioned, the dwell-time paradigm reveals children's segmentation of events – that is, children allocate more attention to breakpoints within action than to moments mid-stream in action. We also know this relates to their memory for events. Thus, utilizing a self-paced slideshow might facilitate children's action segmentation. In a live action or video demonstration, children are forced to process action at a given pace. In a self-paced slideshow, children would have the ability to pause as needed and attend longer to important junctures in action, thus promoting segmentation. This could potentially facilitate their learning over-and-above other forms of learning media. Second, other research has documented that interactive and self-paced learning media are helpful in learning novel information (e.g., Boucheix & Guigard, 2005; Mayer & Chandler, 2001; Zhang et al., 2006). The ability to slow down an event to one's desired pace (perhaps regardless of segmentation efforts) might ease learning and reduce one's cognitive load. Essentially, it could allow more time for processing especially tricky moments of a sequence. For either of these reasons, we might see benefits of the self-paced slideshow in comparison to learning from a medium in which children do not exert any pacing control.

At the same time, it is not a foregone conclusion that a self-paced slideshow will be beneficial to learning. When faced with a novel activity and the challenge of extracting segmental structure, the self-paced slideshow may actually be a poor learning medium. A truly novel event might not be readily segmented, as the learner might lack background information about how the event should unfold (e.g., it might be hard to predict what will happen next and thus hard to meaningfully segment). In other words, when presented with a truly novel action sequence, children may not know how to employ their attention because they lack familiarity with what is going on. In fact, this could have been the reason for no learning being evident in the study by Liu (1996) presented earlier. If this is the case, we might not see benefits of using the self-paced slideshow over-and-above learning from a live person or video.

Furthermore, the video deficit effect has been repeatedly documented across a variety of two-dimensional media and stimuli (see Barr (2010) for a review; picture books: Simcock & DeLoache, 2006). Thus, it seems plausible that the video deficit effect might extend to computer-based media as well, including the slideshow used in the current set of experiments. Thus, even if the self-paced component of the slideshow is unique relative to the other learning media utilized in this dissertation, it is possible that it will not help children overcome the difficulty of transferring knowledge from a 2-dimensional to a 3-dimensional source.

The Current Experiments and Hypotheses

The current study seeks to shed light on how preschool-aged children differentially learn from three types of learning media: live action, self-paced slideshow, and video. In particular, the self-paced slideshow is a new learning medium that has not been previously investigated in terms of its effectiveness – how does it compare to the other learning media?

In Experiment 1, children were exposed to one of three forms of learning media, and then tested on their ability to perform the action sequences and answer a series of verbal memory questions. An additional control condition measured children's ability to perform the action sequences in the absence of any demonstration. I hypothesized that children viewing live demonstrations would be better able to reproduce the actions and show higher memory accuracy than their peers in the video condition. This would be consistent with past literature (e.g., Hayne et al., 2003; Kuhl et al., 2003; McCall et al., 1977). Also in agreement with past literature, I hypothesized that children in all three learning media conditions would show superior performance when compared to their counterparts in the control condition (e.g., Hayne et al., 2003; Strouse & Troseth, 2008).

The main question of interest was how children would perform in the self-paced slideshow condition. An initial goal was to determine whether the video deficit effect extended to this new form of 2-dimensional media, or whether the slideshow was indeed superior to the video. Given past work showing that pausing and controlling the pace act as a learning aid in comparison to an uncontrollable set pace (Boucheix & Guignard, 2005; Hasler et al., 2007; Zhang et al., 2006), I hypothesized that the slideshow would result in superior learning in children when compared to the video.

As for comparing the self-paced slideshow to the live condition, I hypothesized that it might depend on the material to be learned. For instance, given an identical demonstration and identical information available, a simplistic action sequence might be best learned from a live person. However, a more complex causal sequence might be best learned from a self-paced slideshow where children can pause on especially confusing or tricky moments or to consider each step in the causal chain. This option to slow down the flow of information may provide children with extra time to process challenging information when compared to the identical information provided in the form of a continuous demonstration. However, it did seem equally possible that learning from a live person might provide a social environment not possible in the other conditions, and thus the live condition might trump the slideshow in its learning outcomes despite the slideshow's self-paced component.

CHAPTER II

EXPERIMENT 1

Methods

Participants

Seventy-two children participated in this first experiment: thirty-six 3-year olds (*M* = 40.96 months, *range* = 36.07 – 44.63 months, 18 males) and thirty-six 4-year olds (*M* = 55.37 months, *range* = 51.27 – 59.70 months, 17 males), along with their primary caregivers (almost all mothers). All children were typically developing and lived in a college town or its surrounding area. Participants were primarily white and middle-class, and were recruited from a database maintained by the university where the research was conducted. Children were randomly assigned to participate in either the live (*n* = 18), self-paced slideshow (*n* = 18), video (*n* = 18), or control (*n* = 18) condition. Data from four additional children were omitted from final analyses due to a disinclination to participate.

Measures

Verbal ability. Children were given the Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4, Dunn & Dunn, 2007) in which they were asked, for each of a series of items, to select one picture from four options that best illustrated the meaning of an orally presented word.

Inhibitory control. In the day/night task (Gerstadt, Hong, & Diamond, 1994), the experimenter first confirmed that the children associated the sun with day and the moon with night. Children were instructed to say “night” when shown a card depicting a sun against a white background. Children were instructed to say “day” when shown a card depicting a moon and stars against a dark blue background. Two practice trials occurred in which children were shown and labeled one of each image. If the child answered incorrectly, the experimenter reiterated the rules and repeated the practice trials as needed. Following this practice phase, children received 16 test trials in a fixed random order. They were not provided any feedback during this portion. Coding consisted of correct responses out of 16 – saying “day” for the moon and “night” for the sun. One coder coded this task live while a second coder coded 18 of the children from videotape. Agreement between coders was 93%.

The grass/snow task is a similar Stroop-like task requiring children to point instead of speak (e.g., Carlson & Moses, 2001). After confirming that children knew the colors of grass and snow, the experimenter showed the children a large board with a solid white card in one of the two upper corners, and a solid green card in the other upper corner. Two foam cutouts shaped like hands were centered below the cards on the lower half of the board. The experimenter instructed children to point to the green card when she said “snow” and point to the white card when she said “grass.” As with the day/night task, two or more practice trials occurred followed by 16 test trials in the same fixed random order. Coding consisted of correct responses out of 16 – pointing to green for “snow” and while for “grass.” Agreement between the two coders was 95%.

The gift delay task requires children to delay their gratification (Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996). The experimenter told the children that she had a present for them, but it was a surprise. She asked children to face away and not look while she wrapped the gift. Once the child was seated in a chair facing the opposite direction, the experimenter noisily wrapped a gift for 60 seconds. Once 60 seconds had passed, the experimenter invited children to open their present (a small rubber duck). Coding consisted of (1) the total number of times children peeked over their shoulder, (2) the total number of times children fully turned around, and (3) time until the first peek (or 60 seconds for children who didn't peak). Coding reliability between the two coders was 100% for peeking score (never peeked, peeked, turned around fully), 83% for total number of peeks, and 83% for time until first peek (within 2 seconds).

Social understanding questionnaire. The Children's Social Understanding Scale – Long Form (CSUS, Tahiroglu, Moses, Carlson, & Sabbagh, 2009) was used to examine children's social understanding and theory of mind. Parents completed the questionnaire while their children were occupied with the experiment. This questionnaire contains 42 items providing information on six social understanding subscales: Belief, Knowledge, Perception, Intention, Desire, Emotion.

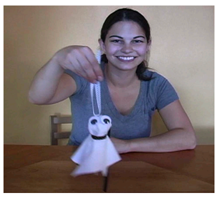
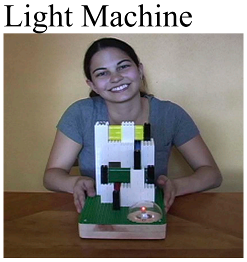
Temperament questionnaire. The Children's Behavior Questionnaire - Short Form (CBQ-SF, Putnam & Rothbart, 2006) was used to examine parental perceptions of child temperament. Parents completed the questionnaire while their children were viewing the demonstrations and imitating the toys. This questionnaire contains 94 items providing information on 15 temperament scales.

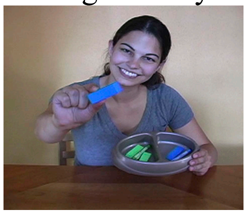
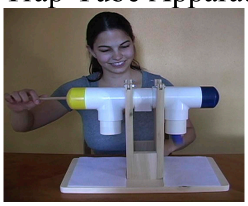
Demonstration Stimuli

Across conditions, children viewed an identical series of events. Nine events were piloted prior to the start of this study, to ensure their appropriateness – e.g, that children were not at ceiling or baseline levels and the event could be embedded into the various learning media. One event was eliminated for being too easy, one event was eliminated for being too difficult, and a final event was eliminated for not being compatible with the slideshow version of the study (the shaking of this particular toy caused by pulling a string was not visible in the slideshow version). Six events remained (see Table 1).

Table 1

Events Used in Experiment 1

Event	Description
Ghost 	The experimenter showed the white felt piece (1), placed the googly eyes on the felt (2), placed the Styrofoam ball under the felt (3), held the ghost around its neck and put a ribbon on top of his head via Velcro (4), tied a ribbon around his neck with Velcro (5), and then held up the completed ghost (6). Number of target actions: 6
Lego Man 	The experimenter put down two legs (1), put on a connecting piece (2), put on a flat stomach piece (3), put on a longer shoulder piece (4), connected two arm pieces to the shoulder (5), and then put on a head piece (6) Number of target actions: 6
Light Machine 	The experimenter placed blocks in a specific order to turn on a light. The order was red (1), green (2), blue (3), yellow (4), then the light came on (5) if the blocks were pushed down all the way. Number of target actions: 5
Playdough Pasta Maker 	The experimenter pushed a middle tube piece into a bottom stand piece (1), rolled some orange Playdough in her hands and put it into the middle tube piece (2), twisted a lid into place on top of the middle tube piece (3), and then pushed down two arms on the middle piece (4) to make Playdough noodles come out of the top piece (5). Number of target actions: 5

Sorting Activity 	The experimenter sorted crayons and erasers one-by-one based on their color (blue or green) into two bowls (1). *See: Williamson, Jaswal, & Meltzoff, 2010 for a similar task* Number of target actions: 1 *(sorted by color)*
Trap-Tube Apparatus 	The experimenter looked inside the yellow hole (1), then used a stick to retrieve a toy from the tube apparatus. The stick had to be inserted into the yellow hole (2) in order to successfully retrieve the toy (3). Putting the stick in the blue hole resulted in the toy becoming trapped inside the apparatus. *See: Modena & Visalbeghi, 1998 or Want & Harris, 2001 for a similar task used with children* Number of target actions: 3

To create the demonstration stimuli, I initially videotaped a female adult (myself) performing each event in live action form. Each event was embedded into a pedagogical context (this included the inclusion of eye contact and verbal cuing) in order to create rich learning conditions.

Live condition. The same female experimenter re-enacted the original videotaping as closely as possible. The experimenter sat at a table with her upper body visible to the child, creating the same image as in the original video. A second experimenter opened a curtain covering her, the experimenter said “Hi there, look at this!”, waved, performed the demonstration, waved again, and said “Look, all done!”. The curtain was then closed. The second experimenter also timed the demonstration, and recorded any instance in which children looked away from the demonstration.

Self-paced slideshow condition. Each event’s video was broken down into still-frame images for the corresponding self-paced slideshow. I extracted still-frame images at 1/10 second intervals from the 30 frame/second action sequence, and then hand selected images from the resulting set that alternated between breakpoint images and moments midstream in action, with breakpoints both starting and ending the set of images. This resulted in 85 frames for the ghost slideshow, 85 frames for the Legos slideshow, 89 frames for the light slideshow, 75 frames for the pasta slideshow, 83 frames for the sorting task slideshow, and 63 frames for the trap-tube apparatus slideshow. A program was created with PsychToolBox Experiments in MatLab that allowed the experimenter to select an event, display the corresponding images on the computer facing children as children clicked through at their own pace, and an online coder to push down a button when children were attending to the computer screen. To match the verbal remarks from the live condition, the first frame of the slideshow remained on the screen while the sound file of "Hi there, look at this!" played. Similarly, the final frame of the slideshow remained on the screen as "Look, all done!" played. The computer utilized the live coder's judgments to record children's attention to the event, including how long children looked at each frame in the sequence.

Video condition. Another MatLab program was created that allowed the experimenter to select an event, display the video on the computer facing children, and an online coder to push down a button when children were attending to the computer screen. Identical to the slideshow condition, the first and last frames froze on the screen as soundbytes played, matching the experimenter's language from the live condition. The computer program again recorded how much children attended to the event.

Control condition. Like the live condition, the experimenter sat at a table with her upper body visible to the child, creating the same image as in the original video. A second experimenter opened a curtain occluding her from the child's perspective, the experimenter said “Hi there, look at this!”, waved, looked at the toy, waved, and said “Look, all done!”. The curtain was then closed. The second experimenter also timed the viewing, and recorded any time the child looked away. The viewing tended to last about 15 seconds for each toy. Children did not see a demonstration of the toy, but did see the experimenter give the toy some attention prior to handing it off to the child.

Procedure

Parents completed the consent process in a playroom as the child played with a variety of toys. Parent and child were then brought across the hall to begin the study.

Parents were seated facing the wall, and thus away from the child and experimenter, working quietly on a set of questionnaires (Social Understanding Questionnaire, Children’s Behavior Questionnaire). Parents were instructed verbally and via an instruction sheet on top of the questionnaires to not interact with their children whatsoever until explicitly instructed to do so. They were asked to keep their eyes on the papers and not look at the events occurring in the room. If their child made a plea for attention, parents were instructed to either ignore the plea or say that “I am busy with these papers, please go back to your game.” I chose to have parents remain in the room so that children were not uncomfortable being left alone. However, I did not want parents to influence their children’s learning nor have significant exposure to the events prior to the teaching component of the session, thus they had to face away from the events at all times.

Slideshow practice. Across conditions, children first had the opportunity to advance through a series of ten slides, using the self-paced slideshow technology. With the slideshow, a practice phase precedes the viewing of the actual test stimuli to ensure that children understand that clicking the mouse advances the image on the screen (Meyer et al., 2011). Thus, the first task for all children was to page through a series of 10 practice slides. To match experience across conditions, all children (regardless of the learning medium they were assigned to) had this opportunity. The practice images were simply the numbers 1-10. Children were told: "I am going to show you some numbers on the screen, and I want you to click the mouse however fast or slow you want in order to change the picture, okay?" For all children, this served as a "countdown" to the demonstration. For those children experiencing the self-paced slideshow, this also gave them exposure to the methodology so that we knew that they understood that the mouse advanced the image prior to viewing the demonstration stimuli. After this, there was an approximately 60-second rest period before the first demonstration.

Demonstration and imitation phase. The format for all conditions was demonstration of event #1 followed by imitation of event #1, then demonstration of event #2 followed by imitation of event #2, and so on until all six events were completed. Children watched the demonstration in one chair, and then moved to a child-sized chair at a child-sized table to perform the imitation task. The imitation portion lasted either 90 seconds or until the child was clearly finished (e.g., exclaimed "done!" or walked away). The order of events was counterbalanced across children and conditions via a Latin Square, resulting in 6 possible orders where each event occurred once in each position.

For the live action demonstrations, children were seated in a chair at a table directly across from the experimenter. The experimenter was far enough back that children could not reach out and grasp the objects. The experimenter then pedagogically performed the event. The experimenter did not respond to any requests or comments made by children during the demonstration in order to make this experience as equivalent as possible to viewing the two-dimensional slideshow or video display.

For the self-paced slideshow demonstration, children were seated in a chair at a table directly in front of a computer monitor. Children paged through each demonstration at their own pace. An eye gaze coder sat behind the computer, hidden by a curtain, to record when the child was looking to and away from the computer monitor.

For the video demonstration, children were seated in a chair at a table directly in front of a computer monitor. The computer monitor played the video at a continuous set pace. An eye gaze coder sat behind the computer, hidden by a curtain, to record when the child was looking to and away from the computer monitor.

For the control condition, children were seated in a chair at a table directly across from the experimenter. The experimenter was far enough back that children could not reach out and grasp the objects. The experimenter then looked at the object without showing its function. The experimenter did not respond to any requests or comments made by the children during the demonstration in order to make this experience as equivalent as possible to viewing the two-dimensional slideshow or video display.

Memory phase. After viewing and imitating all six events, children were asked three questions regarding each event and were expected to provide a verbal response; children were asked about each toy in the same order in which they had interacted with that toy. The questions are listed in Appendix A. Children were first asked the question in open-ended form and given about 3-4 seconds to answer. If children did not respond, they were provided with a forced-choice prompt with two options.

Teaching phase. After the verbal memory test, children were asked to teach their parent how to perform the various actions they had witnessed. Parents were asked to sit at the table with their child, perpendicular to their child's chair. The child had all the props from the event available, one event at a time, in the same counterbalanced order as before. Prior to having their parent join them, the experimenter told children "Okay, I am going to have your mom (dad) come sit with you now, and I want you to teach her (him) about our toys, okay?" The experimenter looked for a signal of comprehension (e.g., a nod), or repeated the instruction. The teaching task lasted for 90 seconds for each event, or until children declared they were finished, whichever came first. The teaching phase's purpose was multifold – in essence, it offered a measure of delayed imitation as well as of the child's memory for each toy.

Individual difference measures. Children then participated in the day/night task followed by the grass/snow task. These two inhibitory control measures lasted approximately 3-5 minutes total. After this, children completed the PPVT-4. Depending on the child's verbal ability, this task varied in length between approximately 5-10 minutes. Lastly, children participated in the gift delay task. This allowed children to finish the experimental session with a gift (a small rubber duck).

Coding and Reliability

Demonstrations. I recorded children's attention to each demonstration to see if attention differed across the three learning media. For the live and control conditions, a live coder used a stopwatch to record these data. For the video and slideshow conditions, a trained coder did this on the computer during the session. The coder was at a coding station behind a curtain, not visible or known to the child, for all conditions. Following the experiment, a second coder viewed 18 of children's experimental sessions on videotape and agreed on 95% of children's look aways from the demonstration.

Imitation and teaching tasks. Children's imitation and teaching performance was coded live for a series of target actions, listed for each toy in Table 1. Following the experiment, a second coder watched 18 of the children perform the target actions on videotape. The second coder agreed with 89% of the first coder's target actions.

Memory task. Children were given memory scores for each toy, specifically a score out of 3 based on how many questions they answered correctly, regardless of whether their answer occurred before or after the prompt.[1] Following the experiment, a second coder re-recorded 18 of the children's memory answers from videotape. The first and second coder agreed on the total memory score 97% of the time.

Results

Preliminary Analyses

The main dependent measures utilized in the present study to gauge learning were children's production of target actions and their verbal memory for the event sequences. Initially, production of target actions was measured in two tasks: an imitation task immediately following the demonstration and a teaching task later on. Though the imitation and teaching tasks were initially adopted as potentially distinguishable measures of children's learning (i.e. children might engage differently with the toy sequences when told to engage in pedagogy), preliminary analyses showed that they were essentially an identical measure of children's learning ($r = 0.94$, $p < 0.001$). Thus, instead

[1] An adjusted memory score out of 6 was also created where 1 point was awarded if the child answered correctly after the prompt and 2 points were awarded if the child answered correctly before the prompt. However, this had no differential effect on analyses conducted in this dissertation.

of reporting analyses on both measures separately (as they were essentially indistinguishable), I created a composite score in which I averaged performance across the two tasks together (referred to simply as children's production of target actions). I also measured proportion of time that children spent attending to the demonstration, as this could potentially provide some interesting insight into condition differences regarding how much different learning media engage children's interest.

Performance Differences Between the Live, Slideshow, and Video Demonstrations

In this section, I will present findings regarding condition differences in children's production of target actions, verbal memory scores, and attention to the demonstration across the three learning media of interest: live, self-paced slideshow, and video. Analyses will be presented in the text, followed by corresponding tables depicting the relevant means and standard deviations. A subsequent section will provide a comparison of performance to the no demonstration control condition as well, to ensure that learning was indeed occurring across learning media when compared to a no demonstration control.

The general approach to examining condition differences was a MANCOVA with Helmert contrasts. Helmert contrasts were theoretically motivated; past work has documented the benefit of live action over 2-dimensional media like video (contrast 1: live versus video/slideshow combined). As well, an objective of this experiment was to discover whether slideshow learning was superior to video learning (contrast 2: video versus slideshow). In the MANCOVA, I included all 18 dependent measures (production of target actions, verbal memory score, and proportion of time attending to the demonstration on each of the 6 toys) with condition entered as the fixed factor. Four covariates were included – age in months, inhibitory control composite (day/night + grass/snow performance), CSUS total score, and PPVT-4 score. These covariates seemed to have individual potential to enhance performance (i.e. an older child or a child more advanced in inhibitory control, theory of mind, and verbal ability might naturally perform better), so the question of interest was whether condition differences existed even with these factors controlled for in the analysis. The MANCOVA revealed significant differences between the three conditions on the dependent measures (Wilks' $\wedge = 0.10$, $F(36,60) = 3.51$, $p < 0.001$, see Figure 1)[2].

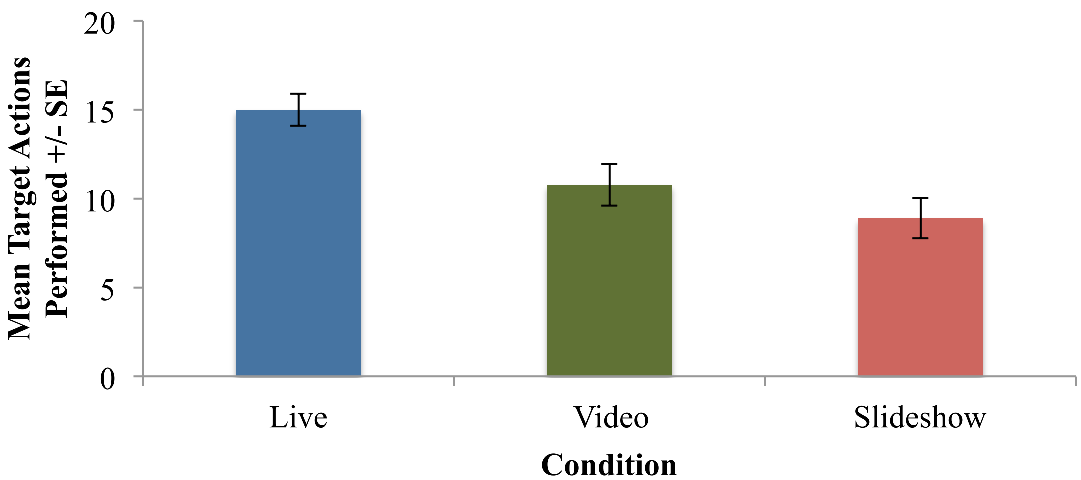


Figure 1. Experiment 1: Mean Production of Target Actions Across Conditions.

Production of target actions on each toy. In terms of children's production of target actions on each of the six toys (see Table 2), the univariate tests from the MANCOVA revealed significant differences between conditions for the ghost ($F(2,47)$ =

[2] An additional MANCOVA was run with only the 12 production of target action and memory measures entered as dependent variables. Overall proportion of time attending to the demonstrations was added as an additional covariate. This analysis revealed an identical pattern of condition differences as those presented in this results section.

12.99, $p < 0.001$), light machine ($F(2,47) = 4.17$, $p < 0.03$), and trap-tube apparatus ($F(2,47) = 23.32$, $p < 0.001$). There were not significant condition differences on the univariate tests for the Lego man ($F(2,47) = 1.86$, $p = 0.17$), Playdough pasta maker ($F(2,47) = 1.85$, $p = 0.17$), or sorting toy ($F(2,47) = 1.51$, $p = 0.23$), though means across the toys all showed roughly the same pattern.

Table 2

Experiment 1: Production of Target Actions by Toy and Condition

	Live M (SD)	Video M (SD)	Slideshow M (SD)
Ghost* *(6 possible actions)*	3.69 (1.34)	1.56 (1.52)	2.14 (1.32)
Lego *(6 possible actions)*	3.97 (2.10)	3.50 (2.35)	2.53 (2.42)
Light* *(5 possible actions)*	1.61 (1.14)	0.78 (0.96)	0.67 (1.07)
Pasta *(5 possible actions)*	2.61 (1.36)	2.33 (1.60)	1.89 (1.46)
Sorting *(1 possible action)*	0.89 (0.27)	0.81 (0.39)	0.72 (0.43)
Trap-Tube* *(3 possible actions)*	2.22 (0.65)	1.81 (0.55)	0.94 (0.54)
Overall	15.00 (3.86)	10.78 (4.98)	8.89 (4.82)

* $p < 0.05$ on univariate test of condition differences

For the first contrast, significant differences emerged between the live and slideshow/video conditions combined on the ghost, light machine, and trap-tube apparatus (p's < 0.01), such that children produced more target actions in the live condition than in the slideshow/video conditions. No significant differences emerged between conditions for the Lego man, Playdough pasta maker, and sorting toys (p's > 0.05).

For the second contrast, the video and slideshow conditions significantly differed only for the trap-tube apparatus ($p < 0.001$), with lower performance in the slideshow condition. No other significant differences emerged with the second contrast (p's > 0.05), though 5 of the toys had higher means in the video condition.

Verbal memory for each toy[3]. As for children's verbal memory for each toy (see Table 3), the univariate tests suggested that a marginal difference between conditions only existed for the Lego man ($F(2,47) = 2.55$, $p < 0.10$). There was no difference between conditions on the ghost ($F(2,47) = 0.12$, $p = 0.89$), light machine ($F(2,47) = 1.20$, $p = 0.31$), Playdough pasta maker ($F(2,47) = 0.96$, $p = 0.39$), sorting toy ($F(2,47) = 0.48$, $p = 0.62$), or trap-tube apparatus ($F(2,47) = 0.87$, $p = 0.42$). For contrast 1, there were no differences in memory score between live versus slideshow/video combined (p's > 0.05). For contrast 2, though there was no difference in overall memory score for five of the toys (p's > 0.10), there was a nearly significant difference between the video and slideshow conditions on the Lego man ($p = 0.053$), such that memory was marginally better in the video condition, and this same direction of effects did appear in the means for 5 of the 6 toys.

Attention to the demonstration for each toy. Lastly, for children's attention to the demonstration for each toy (see Table 4), the univariate tests from the MANCOVA revealed significant differences between conditions for the ghost (F (2,47) = 4.82, $p <$ 0.02), light machine (F (2,47) = 4.16, $p < 0.03$), Playdough pasta maker (F (2,47) = 6.51,

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[3] As mentioned earlier, given that children were first given the opportunity to answer an open-ended question before being supplied with a prompt, there was the potential to create a second memory measure where children were given an additional point for answering without a prompt. However, this measure and the raw memory score were highly correlated ($r = 0.98$, $p < 0.001$), and it was relatively infrequent to answer prior to the prompt), so those results are not discussed separately here.

$p < 0.01$), sorting toy (F (2,47) = 4.47, $p < 0.02$), and trap-tube apparatus (F (2,47) = 6.71, $p < 0.01$). There was also a marginally significant difference between conditions for the Lego man (F (2,47) = 2.57, $p < 0.09$).

Table 3

Experiment 1: Verbal Memory Scores by Toy and Condition

	Live M (SD)	Video M (SD)	Slideshow M (SD)
Ghost	2.22 (0.88)	2.28 (0.75)	2.06 (0.94)
Lego*	2.22 (0.81)	2.17 (0.86)	1.67 (0.91)
Light	2.28 (0.83)	2.11 (0.76)	1.83 (0.99)
Pasta	2.11 (0.76)	2.11 (0.96)	1.72 (0.83)
Sorting	2.17 (0.92)	2.11 (0.90)	2.28 (0.83)
Trap-Tube	2.44 (0.78)	2.22 (0.81)	2.06 (0.80)
Overall	13.44 (2.43)	13.00 (3.46)	11.81 (2.59)

* $p < 0.10$ on univariate test of condition differences

For the contrast 1 comparison between live versus combined slideshow/video, significant differences in attention were found on the ghost, Lego man, light machine, and trap-tube apparatus (p's < 0.05) and marginal differences on the Playdough pasta maker and sorting toy (p's < 0.10), such that children attended longer in the live condition than in the video/slideshow conditions combined. For the contrast 2 comparison between slideshow and video, significant differences were found on the ghost, Playdough pasta maker, sorting, and trap-tube apparatus (p's < 0.05), such that children attended more during the video condition. Proportion of time spent attending to the demonstration did not differ for the Lego man or light machine between the video and slideshow conditions (p's > 0.05). It is worth noting that children's attention was near ceiling, in that attention ranged only from 86% - 100% and most toys involved children attending to over 90% of the demonstration.

Table 4

Experiment 1: Proportion of Time Attending to the Demonstration by Toy and Condition

	Live M (SD)	Video M (SD)	Slideshow M (SD)
Ghost**	0.999 (0.006)	0.99 (0.02)	0.94 (0.09)
Lego*	0.999 (0.005)	0.97 (0.04)	0.96 (0.08)
Light**	0.99 (0.02)	0.95 (0.08)	0.92 (0.11)
Pasta**	0.998 (0.008)	0.99 (0.02)	0.92 (0.12)
Sorting**	0.99 (0.02)	0.98 (0.04)	0.86 (0.24)
Trap-Tube**	0.998 (0.007)	0.99 (0.02)	0.89 (0.16)
Overall	0.997 (0.006)	0.98 (0.02)	0.92 (0.07)

** $p < 0.05$, * $p < 0.10$ on univariate test of condition differences

Developmental differences. In order to determine if the reported findings differed based on the age of the children, the preceding MANCOVA analysis was rerun with age group entered as a fixed factor instead of age in months being included as a covariate. There were no significant differences in performance on the dependent measures across the two age groups (Wilks' $\wedge = 0.53$, $F(18, 30) = 1.47$, $p = 0.17$), suggesting that the 3-year-old and 4-year-old children performed similarly on these tasks.

Individual Difference Measures

Another question of interest was how individual differences related to children's performance. Partial correlations were computed between children's scores on the individual difference measures and children's production of target actions, their verbal memory score, and proportion of time attending to the demonstration. Age and verbal ability were controlled when looking at theory of mind and inhibitory control measures. Looking to other research using individual difference measures pertaining to theory of mind and inhibitory control, it is typically the norm to control for both age and verbal ability in analyses (e.g., Carlson & Moses, 2001; Pellicano 2007; 2010) since skill in these realms improves with age. With the CBQ, it is typical to just control for age (e.g., Goldsmith & Lemery, 2000; Schwebel & Plumert, 1999), so correlations here were conducted accordingly. A Bonferroni correction was also applied within each individual difference measure, to account for the numerous correlations conducted.

Theory of mind: CSUS. Twenty-one partial correlations were conducted relating each of the 7 CSUS measures to the 3 performance measures, with a required p-value of 0.002 or lower to reach significance after the Bonferroni correction. Partial correlations (controlling for age and verbal ability) between the subscales of the CSUS and children's total production of target actions, verbal memory score, and proportion of time attending revealed no significant relations when looking at both the whole sample or within conditions (p's > 0.002).

Temperament: CBQ. Forty-five partial correlations were conducted relating each of the 15 CBQ scales to the 3 performance measures, with a required p-value of 0.001 or lower to reach significance after the Bonferroni correction. Partial correlations (controlling for age) between the subscales of the CBQ and children's production of target actions, verbal memory score, and proportion of time attending revealed no significant relations when looking at both the whole sample or within conditions (p's > 0.001).

Verbal ability: PPVT-4. Three partial correlations were conducted relating PPVT-4 score to the 3 performance measures, with a required p-value of 0.017 or lower to reach significance after the Bonferroni correction. Partial correlations (controlling for age) between scores on the PPVT-4 and children's production of actions, verbal memory for action, and proportion of time attending to the demonstration showed a significant positive relation between PPVT-4 score and children's verbal memory score as well as a marginal positive relation between PPVT-4 score and children's production of target actions (see Table 5). I also looked at partial correlations within each condition, though these were less powerful analyses given only 18 children per condition. Still, verbal memory score and PPVT-4 score were positively related across all learning media. There were no significant relations between PPVT-4 score and children's proportion of time attending to the demonstration (p's > 0.017).

Table 5

Experiment 1: Correlations Between Verbal Ability and Performance Measures

	Overall	Live	Video	Slideshow
Target Actions	0.30*	0.49*	0.34	0.33
Verbal Memory	0.55**	0.67**	0.58**	0.48*

** $p < 0.017$ * $p \leq 0.05$

Inhibitory control: Day/night, grass/snow, and gift delay. Fifteen partial correlations were conducted relating the 5 inhibitory control measures to the 3 performance measures, with a required p-value of 0.003 or lower to reach significance after the Bonferroni correction. Partial correlations (controlling for age and verbal ability) between the scores on the inhibitory control measures (day/night task, grass/snow task, and gift delay task – including number of peaks, number of turn-arounds, and time until first peak) and children's production of target actions, verbal memory score, and proportion of time attending to the demonstration showed no significant relations (p's > 0.003). When analyzed by condition, no significant correlations emerged (p's > 0.003).

Predicting Successful Production and Memory

A remaining question of interest was whether condition and individual difference measures made unique contributions to children's learning when controlling for the other variables. A multiple regression approach here seemed to have the benefit of testing for such unique contributions of the given variables while holding other variables constant, while also ascertaining the proportion of variance in performance accounted for by a given set of variables. Two stepwise multiple regressions were conducted: one on target actions and one on verbal memory score. In step 1, the predictors were age in months, PPVT-4 score, CSUS total score, and inhibitory control composite. In step 2, condition was added as a significant predictor in order to ascertain its unique contribution. Condition was entered as a block with two dummy coded variables – live versus video/slideshow and video versus slideshow (similar to the theoretically motivated Helmert contrasts used earlier in the MANCOVA).

The first model with four predictors in a stepwise multiple regression with production of target actions as the dependent measure accounted for 43.6% of the variance in performance ($F(4,49)=9.48$, $p < 0.001$). Age in months was a significant predictor ($t(49) = 3.62$, $p = 0.001$) and PPVT-4 score was a marginally significant predictor ($t(49) = 1.67$, $p = 0.10$). In the second model with condition added, PPVT-4 score ($t(47) = 2.15$, $p < 0.04$) and age in months ($t(47) = 4.34$, $p < 0.001$) were both significant predictors along with condition; live versus video/slideshow was a significant predictor ($t(47) = -5.34$, $p < 0.001$) while slideshow versus video was a marginally significant predictor ($t(47) = 1.76$, $p < 0.09$). This new model explained a significantly higher amount of variance; specifically, it explained an additional 22.6% of the variance, for a total of 66.2% of the variance in production of target behaviors explained ($F(6,47) = 15.34$, $p < 0.001$).

When using verbal memory score as the dependent measure, the first model with four predictors accounted for a significant 52.6% of the variance in memory score ($F(4,49) = 13.61$, $p < 0.001$). In this first model, only PPVT-4 score was a significant predictor ($t(49) = 2.97$, $p < 0.01$). Age in months was a marginal predictor ($t(49) = 1.98$, $p < 0.06$). In the second model with condition added as a potential predictor, only PPVT-4 score was a significant predictor ($t(47) = 3.17$, $p < 0.01$) with age in months again emerging as a marginal predictor ($t(47) = 1.99$ $p < 0.06$). The new model accounted for 57.3% of the variance, a nonsignificant increase of 4.7% ($F(2,47) = 2.59$, $p < 0.09$).

Comparing the Learning Media to the No Demonstration Control

An additional multivariate analysis of variance was conducted with 6 dependent measures (production of target actions for each of the 6 toys) and condition entered as the fixed factor, with the control condition now included as well in order to ascertain whether learning had occurred in the three learning media conditions. The omnibus outcomes here were of less interest given that I already conducted a MANCOVA earlier with 3 of the 4 conditions (and indeed all the dependent measures again reached significance), but the new information to consider was derived from the Dunnett's post-hoc tests conducted with this analysis. Dunnett's post-hoc test is specifically designed for situations where all conditions are pitted against a reference group – in this case, the no demonstration control (see Figure 2). As depicted in Table 6, most pairwise comparisons between each learning medium versus the control group reached significance, pointing to children learning from the three media when compared to having no demonstration. Only 1 pairwise comparison (on the trap-tube apparatus in the slideshow) did not reach significance.

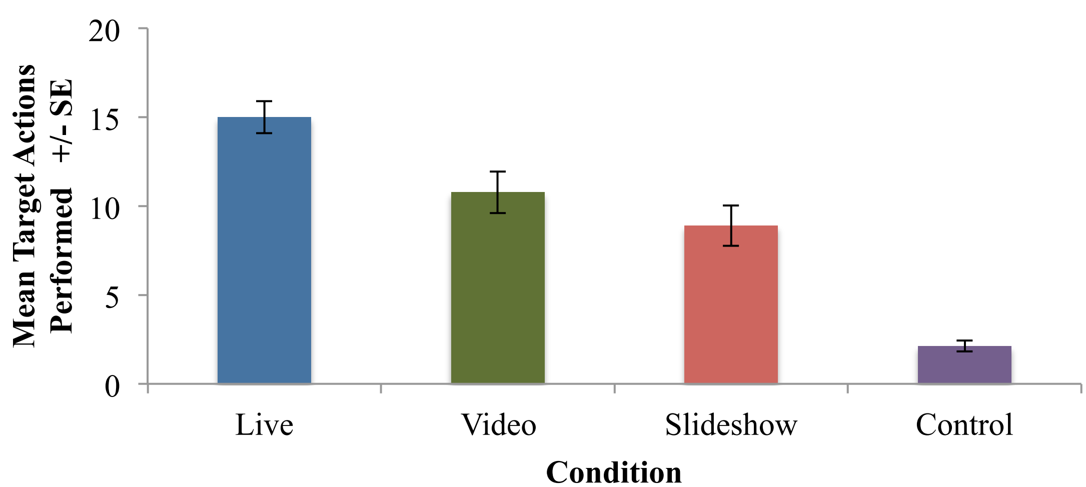


Figure 2. Experiment 1: Mean Production of Target Actions in the Three Learning Media versus the No Demonstration Control.

Table 6

Experiment 1: Comparing Target Actions Between the Learning Media and the Control Group

	Live M (SD)	Video M (SD)	Slideshow M (SD)	Control M (SD) REFERENCE GROUP
Ghost *(6 possible actions)*	3.69 (1.34) **	1.56 (1.52) *	2.14 (1.32) **	0.61 (0.47)
Lego *(6 possible actions)*	3.97 (2.10) **	3.50 (2.35) **	2.53 (2.42) **	0.38 (0.68)
Light [a] *(5 possible actions)*	1.61 (1.14) [a]	0.78 (0.96) [a]	0.67 (1.07) [a]	0 (0) [a]
Pasta *(5 possible actions)*	2.61 (1.36) **	2.33 (1.60) **	1.89 (1.46) **	0.36 (0.38)
Sorting *(1 possible action)*	0.89 (0.27) **	0.81 (0.39) **	0.72 (0.43) **	0.03 (0.12)
Trap-Tube *(3 possible actions)*	2.22 (0.65) **	1.81 (0.55) **	0.94 (0.54)	0.75 (0.72)
Overall	15 (3.86)	10.78 (4.98)	8.89 (4.82)	2.13 (1.31)

[a] For the light machine, no child in the control condition performed any target action. Given no variance in the control group, I utilized a nonparametric Kruskal-Wallis test to provide insight on whether the number of children performing target actions differed between groups. For the light machine, the number of children (out of 18) performing at least one target action was 16 in the live condition, 11 in the video condition, 9 in the slideshow condition, and 0 in the control condition. The Kruskal-Wallis test confirmed that these numbers were significantly different from one another (χ^2 (3, n = 72) = 29.36, $p < 0.001$). Given this significant result and that no child in the control condition performed any target action on the light machine, it appears that learning did occur in the other three learning media conditions. The next closest number was 9 (or half) of children in the slideshow condition performing a target action, which seems to be a notable difference.
** $p < 0.05$, * $p < 0.10$ when compared to the control condition

Segmentation of the Slideshow

For the 18 children participating in the slideshow condition, I looked more closely at the data to see whether children were using the learning medium to help them segment the action. A paired-samples t-test comparing children's dwell times to slides depicting breakpoints in action versus within-unit slides was not significant ($t(17) = -0.25$, $p = 0.80$).[4] In other words, there was not any evidence of segmentation by the children.

In addition, it appeared that children were advancing through the slideshows very quickly. A MANOVA with duration of the demonstration for each of the 6 toys entered as dependent measures and condition entered as a fixed factor suggested that duration significantly differed between conditions (Wilks' $\Lambda = 0.30$, $F(12, 92) = 6.32$, $p < 0.001$). The univariate tests suggested differences between conditions for all toys: ghost ($F(2,51) = 16.69$, $p < 0.001$), Lego man ($F(2,51) = 14.00$, $p < 0.001$), light machine ($F(2,51) = 31.67$, $p < 0.001$), Playdough pasta maker ($F(2,51) = 8.60$, $p = 0.001$), sorting toy ($F(2,51) = 16.47$, $p < 0.001$), and the trap-tube apparatus ($F(2,51) = 6.11$, $p < 0.05$). For all toys, post hoc comparisons using the Tukey HSD test indicated that the mean duration of the demonstration for the slideshow condition was significantly lower than the mean duration of the demonstration in both the video and live conditions (p's < 0.05). However, as would be expected given how scripted the demonstrations were, the mean duration of the demonstration for the live and video conditions did not significantly differ for any toy (p's > 0.05).

It should be briefly mentioned that, given these differences in duration, one might be concerned that condition differences would no longer exist if duration were taken into account. To rule out this possibility, it should be noted that separate ANCOVAs (with Helmert contrasts) were conducted on each toy (with the respective duration of each toy added in as a covariate); these analyses produced an identical pattern of results to those

[4] Paired sample t-tests comparing dwell times to breakpoints and within-unit slides for each of the six toys individually confirmed that children were not segmenting any of the slideshows.

just described. Thus, condition differences noted in production of target actions were not merely a result of differences in duration of the demonstrations.

Table 7

Experiment 1: Duration of Demonstration (in Seconds)

	Live M (SD)	Video M (SD)	Slideshow M (SD)
Ghost*	44.33 (4.09)	50.71 (0.6)	31.78 (16.82)
Lego*	47.61 (3.26)	47.63 (0.57)	32.34 (13.34)
Light*	51.44 (3.48)	58.76 (0.003)	33.91 (16.30)
Pasta*	40.94 (3.21)	39.26 (0.27)	30.98 (12.98)
Sorting*	45.56 (4.98)	44.85 (0.10)	33.23 (11.50)
Trap-Tube*	33.78 (3.42)	34.16 (0.002)	25.68 (13.81)

* $p < 0.05$ on univariate test of condition differences

Discussion

Children's performance after witnessing demonstrations across the three learning media was superior to their performance when no demonstration was provided, suggesting that learning successfully occurred across learning media conditions. Findings from the first experiment generally point to children showing superior learning from the live demonstration relative to the slideshow and video demonstrations in terms of performing target actions on the toys. This seemed to depend on the nature of the toy, however, as production of target actions in the live condition did not always supersede production in the other conditions (for 3 of the 6 toys). It is noteworthy that a larger sample size might result in finding effects on all six toys, as mean target actions on each toy were highest in the live condition. It is also worthy of note that the three toys that did not display condition differences (specifically, the Playdough pasta maker, Lego Man, and sorting toys) were the three sequences that children had the easiest time performing. These three toys might be more familiar to children and thus result in higher rates of target actions across the learning media.

Memory scores, in contrast to production of target actions, were relatively consistent across conditions. That is, while type of learning medium had a direct impact on children's ability to perform what they had witnessed, it did not have such a differential effect on their ability to verbally report what they saw in the demonstration. Other studies investigating learning media have also sometimes reported no differential effects on children's memory (e.g., Boucheix & Guignard, 2005; Calvert et al., 2005). It is striking that, though children were not scoring perfectly, they were consistently scoring in the upper half of the memory scale and variability was relatively low in Experiment 1. Thus, it is possible that children's verbal memory was close to ceiling levels, and for this reason condition differences did not emerge. Conversely, variability was high in terms of production of target actions on the toy. One way to think about these findings is that the measure of production of target actions was sensitive to developmental change and differences between children, while memory was close to ceiling and thus not sensitive to developmental change. Perhaps a more difficult memory test would have led to differential findings between conditions.

The proportion of time children spent attending to the demonstration was also relatively high across conditions, but children in the slideshow condition attended significantly less to the demonstration. This is perhaps in contrast to the work by Calvert et al. (2005) who found that children attended more to a computer storybook when they had control over the pace of the presentation than when an adult maintained control. It is noteworthy that children's attention in Experiment 1 was near ceiling. My earlier analyses showed that children typically attended for 90% or more of the duration of each demonstration. Thus, even though children attended for a significantly lower proportion of time to the demonstrations in the slideshow condition than in the live and video conditions, attention level was still markedly high.

The design of this experiment also made it possible to examine relations between performance and several individual difference measures. However, the only relations of note were a positive correlation between verbal ability and both children's verbal memory as well as their production of target actions. This seems to indicate that children with excellent verbal skills tended to do better on these types of tasks.

In order to get a clear sense of what individual factors were predicting children's success at producing the target actions and performing well on the verbal memory task, I also ran a multiple regression. This analysis revealed significant predictors of children's success, while controlling for the other factors. In regard to production of target actions, significant predictors included children's verbal ability, their age, and the form of learning media they were receiving. In regard to verbal memory, vocabulary was the biggest predictor with age seemingly playing a role as well. Thus, older children with high verbal ability in the live condition likely performed with the most success in the present experiment in terms of producing the target actions. Conversely, condition did not significantly predict memory performance, so older children with high verbal ability across conditions likely performed equally well.

Altogether, findings from the present research indicate that, as in past research, children learn best from a live source (e.g., Hayne et al., 2003). To thus return to the question at-hand in this dissertation, where does the slideshow fit in as a learning medium? Generally, in terms of production of target actions, it seemed to result in lower levels of learning in comparison to viewing a live demonstration and equivalent learning to viewing a video demonstration. The question remains, then, why didn't the slideshow produce superior learning to the video? As other research has shown, the slideshow adds a level of self-control not possible in a video (e.g., Boucheix & Guignard, 2005), thus one might think that it should lead to superior learning.

There are numerous reasons why the slideshow might not have aided children's learning over-and-above the video. One possibility is that something about the slideshows utilized in the present study were not conducive to learning. Consistent with this possibility, unlike the prior child study that used a slideshow and found patterns indicating that children were segmenting the events (Meyer et al., 2011), there was no evidence of segmentation in children's dwell-time patterns as they moved through the slideshows in Experiment 1. Furthermore, I extracted slides in a different manner than this prior study, specifically alternating between breakpoints and midstream images in an attempt to provide the richest information possible. This is thus another possible reason why the slideshow may not have been particularly effective in eliciting segmentation in children. Perhaps a more natural flow of action where frames were extracted at a set rate (e.g., 2 or 3 frames per second) would provide an easier set of images to segment. Past work has shown that both adults and children spontaneously segment that type of slideshow (Hard et al., 2011; Meyer et al., 2011).

In addition, perceptual processing may have been most challenging in the slideshow condition, and the pedagogical cues and emotional expressions embedded into the event sequences might have distracted children from the actual events in the slideshow. In other words, children might have been drawn to the hands or eyes on the slides instead of attending to the actual event occurring. This could, of course, also be the case with the other conditions – children looking more to the person than the object. However, the smoother flow of action in the other conditions might have also made it easier for children to focus on the objects instead of the person (e.g., the transitions to emotions flowed better as opposed to suddenly appearing on the person's face on the next slide). Indeed, a group of adults reported that the slideshow was somewhat choppy and that they were drawn to the emotions of the actor given that expressions would suddenly appear in the slideshow as opposed to slowly transitioning from one facial expression to another expression as in the live and video conditions. Thus, the somewhat disjointed flow of the slideshow condition could have interfered with perceptual processing. Whether or not children actually did this is difficult to glean from my data set given that I did not use eye-tracking technology. However, it seems like a plausible hypothesis, and could have potentially detracted from children's processing of the information.

A third and final hypothesis is that the slideshow limits the amount of information that children are receiving. In other words, children are only seeing specific frames of an action sequence, so small pieces of information are missing from the stream of action. Including additional slides would solve this problem to some extent. However, then the slideshow might become too taxing for children; there were already close to 500 slides included in the present study that children had to click through, and more slides might cause children to lose interest.

With these possibilities in mind, a second experiment was designed to address the first two possibilities in particular – the impact of the format of the slideshow and the possible interference of pedagogical cues and facial expressions. The events were re-filmed such that pedagogical cues were no longer embedded into the demonstrations; a person was still present and acting out the sequences. However, she was no longer making eye contact, pointing, or providing starting and ending verbal remarks. I also extracted frames at a set pace – 2 frames per second – in order to promote a more natural flow of action that children might have an easier time segmenting into meaningful units. These two components are very similar to the method used for slide creation in Meyer et al. (2011).

Given that the slideshow and video resulted in similar patterns of learning in the first experiment, I opted to just compare these two conditions in the second experiment in order to get a better sense of how the slideshow fits into the picture and to ascertain whether the well-documented video deficit effect truly extends to the slideshow format. Also, the trap-tube apparatus and ghost event sequences were dropped. The trap-tube apparatus was removed due to its inherently pedagogical and expressive demonstration (the actor provided nodding cues to indicate the correct and incorrect sides of the tube, and showed surprise on her face to indicate that something was inside of the tube). The ghost event sequence was dropped due to (1) children having great difficulty with connecting the ribbons to the ghost, and (2) a group of adults reporting difficulty with segmenting that particular action. Eliminating two events also reduced the demands on the child learner, as the length of the first experiment might have worn children out to some extent (typical sessions lasted 75 minutes; this was reduced to 60 minutes with 2 toys dropped).

Two other key changes were made for Experiment 2. First, it is possible that I was not tapping an age group that would find the slideshow technology helpful. Thus, I opted to use 3-year-old children (for the sake of replication) and 5-year-old (for the sake of extension) in the second experiment. This also seemed interesting given that age was a significant predictor of performance in the multiple regression analysis. Second, during Experiment 1, I had informally noticed that some children were more fluent computer users than others, and some parents had reported significant experience with technology while others reported that no screen time was ever permitted in the home. To that end, I designed a computer questionnaire for Experiment 2 to specifically tap that type of information, so that I could look at learning differences between children familiar versus unfamiliar with the technology (see Appendix B).

With this new version of the slideshow, I hypothesized that children would now readily segment the action sequences, given my changes to make the slideshow format more similar to past work showing segmentation patterns in children (Meyer et al., 2011). Given this, I also hypothesized that children's production of target actions would now be higher after viewing a slideshow than after viewing a video. Given the results of Experiment 1, I did not expect to see differences in verbal memory score.

CHAPTER III

EXPERIMENT 2

Methods

Participants

Sixty-four children participated in the second experiment: thirty-six 3-year olds (*M* = 40.88 months, *range* = 36.07 – 46.83 months, 15 males) and thirty-six 5-year olds (*M* = 65.69 months, *range* = 60.57 – 71.63 months, 20 males), along with their primary caregivers (all mothers). All children were typically developing and lived in a college town or its surrounding area. Participants were primarily white and middle-class, and were recruited from a database maintained by the university where the research was conducted. Children were randomly assigned to participate in either the self-paced slideshow (*n* = 16 per age group, 32 total) or video (*n* =16 per age group, 32 total) condition. Data from one additional child were omitted from final analyses due to a disinclination to participate.

Measures

Tasks with children. Measures of verbal ability (PPVT-4) and inhibitory control (day/night, grass/snow, gift delay) were identical to the first experiment. Coder agreement on the day/night task was 93%. Coder agreement on the grass/snow task was 98%. For the gift delay task, coding agreement was 83% on the peeking score, 94% for total number of peeks, and 89% for time until first peek (within 2 seconds).

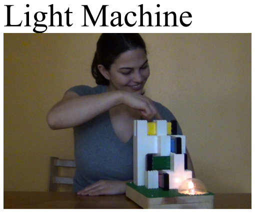
Parent questionnaires. Parents again completed the CSUS and CBQ. However, an additional questionnaire was introduced, looking at the use of computers and related media in the home. This questionnaire was specifically designed to gain understanding of children's prior exposure to the computer and a computer mouse, so that comparisons could be drawn between proficient versus new computer users. A copy of this questionnaire is in Appendix B.

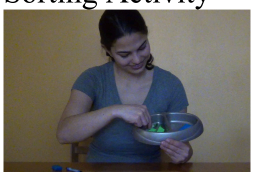
Demonstration Stimuli

Across the two conditions, children viewed an identical series of events. Each event depicted a female (the same actor as in Experiment 1) performing an action sequence. The female would look forward and wave, perform the action with a consistent smile on her face but no pedagogical cues or eye contact to engage the child, and then wave again. Four events were utilized in the second experiment – specifically the Lego man, light machine, Playdough pasta maker, and sorting toy. Table 8 describes the events and their target actions. The order of events was counterbalanced across children of different ages and across conditions via a Latin Square that created 16 possible orders.

Table 8

Events Used in Experiment 2

Event	**Description**
Lego Man 	The experimenter put down two legs (1), put on a connecting piece (2), put on a flat stomach piece (3), put on a longer shoulder piece (4), connected two arm pieces to the shoulder (5), and then put on a head piece (6) Number of target actions: 6
Light Machine 	The experimenter placed blocks in a specific order to turn on a light. The order was red (1), green (2), blue (3), yellow (4), then the light came on (5) if the blocks were pushed down all the way. Number of target actions: 5

Playdough Pasta Maker 	The experimenter pushed a middle tube piece into a bottom stand piece (1), rolled some orange Playdough in her hands and put it into the middle tube piece (2), twisted a lid into place on top of the middle tube piece (3), and then pushed down two arms on the middle piece (4) to make Playdough noodles come out the top piece (5). Number of target actions: 5
Sorting Activity 	The experimenter sorted crayons and erasers one-by-one based on their color (blue or green) into two bowls (1). *See: Williamson, Jaswal, & Meltzoff, 2010 for a similar task* Number of target actions: 1 *(sorted by color)*

To create the demonstration stimuli, a female adult was videotaped performing each event in live action form.

Self-paced slideshow condition. Each event's video was broken down into still-frame images for the corresponding self-paced slideshow. I extracted still-frame images at a rate of 2 per second (this is different from Experiment 1's hand selection of appropriate frames). This resulted in 84 frames for the Lego man, 60 frames for the light machine, 64 frames for the Playdough pasta maker, and 95 frames for the sorting task. The same computer program as in Experiment 1 was utilized, except no soundbytes preceded or followed the children's viewing of the slides in order to make the events less pedagogical in nature and more in line with the stimuli utilized in Meyer et al. (2011). The computer again recorded how much the child attended to the event, including how long the child looked at each frame in the sequence.

Video condition. The same computer program as in the first experiment was utilized. The computer again recorded how much the child attended to the event.

Stimulus Verification

Findings from the prior experiment suggested that children were not readily segmenting the action sequences. Thus, one concern going into the second experiment was that the new demonstration stimuli would be met with the same outcome. In other words, it seemed plausible that extracting segmental structure from these particular action sequences might simply be challenging. To shed some light on this particular concern, I had 24 adults (college undergraduates) advance through the new slideshows prior to starting with children in Experiment 2. I then analyzed their dwell times to the four events. The adults showed longer dwell times to the breakpoint slides over the within-unit slides for the Lego man ($t(23) = -2.45$, $p < 0.03$), light machine ($t(23) = -3.16$, $p < 0.01$), and Playdough pasta maker ($t(23) = -2.65$, $p < 0.02$).

At first glance, it seemed that adults were not segmenting the sorting task ($t(23) = -0.173$, $p = 0.87$). However, when asked to nominate breakpoints in action, the adults often reported only putting in the first 2-3 pieces (green crayon, blue eraser, blue crayon) as meaningful junctures, as that was the information they needed to predict all the subsequent steps (that the woman would continue to sort by color and not another dimension). Thus, when I reanalyzed the dwell times with the breakpoints only including the first three pieces placed into the bowls, adults did show segmentation patterns – looking longer to breakpoint slides than the within-unit slides ($t(23) = -2.83$, $p < 0.01$). Thus, adults segmented all the slideshows to be used in Experiment 2, indicating that the actions were capable of being segmented into meaningful parts. With that in mind, the new demonstration stimuli seemed appropriate.

Procedure

The procedure was largely identical to Experiment 1, with a couple of minor changes. One, the parents had the additional questionnaire on their clipboard to complete. Two, children viewed only four toys instead of six. Third, the slideshow practice was altered to increase it in length (i.e. give children more familiarity with the medium) and to use slides known to elicit segmentation in children; the slides were identical to those used in Meyer et al. (2011). Children viewed a total of 129 slides during this practice phase. As in Experiment 1, children in both conditions participated in this slideshow practice.

Coding and Reliability

Coding and reliability were performed identically to Experiment 1. A live coder was present during the experimental sessions, and a second coder reviewed 18 of the videotapes at a later date. For the demonstrations, the live coder and the second coder agreed on 96% of the look aways. For the imitation and teaching tasks, the second coder agreed with 93% of the initial coder's target action judgments. For the memory task, the two coders agreed on the total memory score 85% of the time.

Results

Performance Differences Between the Slideshow and Video Demonstrations

The main question of interest in Experiment 2 was whether or not children's learning from the self-paced slideshow differed from children's learning from video, given these alterations made to the stimuli. In this section, I present the findings regarding condition differences in children's production of target actions, verbal memory scores, and proportion of time attending to the demonstration. As in Experiment 1, production of target actions represents an averaged composite of target actions performed during the imitation and teaching tasks, as performance was again highly correlated across the two tasks ($r = 0.92$, $p < 0.001$), suggesting that they were relatively indistinguishable constructs of learning. The general analysis strategy was identical to Experiment 1. Specifically, a multivariate analysis of covariance (MANCOVA) was conducted with 12 dependent measures (production of target actions, verbal memory score, and proportion of time spent attending for each of the four toys), condition entered as the fixed factor, and four covariates: age in months, CSUS total score, inhibitory control composite, and PPVT-4 score. No contrasts were necessary this time, as Experiment 2 only had two conditions, allowing for directional conclusions to be drawn given the results of the MANCOVA and its univariate tests. In this second experiment, the omnibus MANCOVA revealed a marginally significant difference between conditions on the dependent measures (Wilks' $\Lambda = 0.673$, $F(13,46) = 1.72$, $p = 0.09$, see Figure 3), such that children in the video condition were somewhat outperforming their peers in the self-paced slideshow condition.[5]

Production of target actions on each toy. In terms of number of target actions produced on each toy (see Table 9), the univariate test for the Playdough pasta maker was significant ($F(1,58) = 15.79$, $p < 0.001$) while the univariate test on the Lego man was marginally significant ($F(1,58) = 2.82$, $p < 0.10$). For these two toys, production of target

[5] An additional MANCOVA was run with only the 8 production of target action and verbal memory measures entered as dependent variables. Overall proportion of time attending to the demonstrations was added as an additional covariate. This analysis revealed an identical pattern of condition differences as those presented in this results section. It is worth noting that the omnibus MANCOVA changed from marginally significant to significant in this alternative analysis (Wilks' $\Lambda = 0.74$, $F(8,50) = 2.25$, $p < 0.04$).

actions was higher in the video condition than in the slideshow condition. The univariate tests on the light machine ($F(1,58) = 0.46$, $p = 0.50$) and sorting toy ($F(1,58) = 0.15$, $p = 0.71$) did not reach significance, suggesting that number of target actions performed was equivalent across the two conditions for these two toy sets.

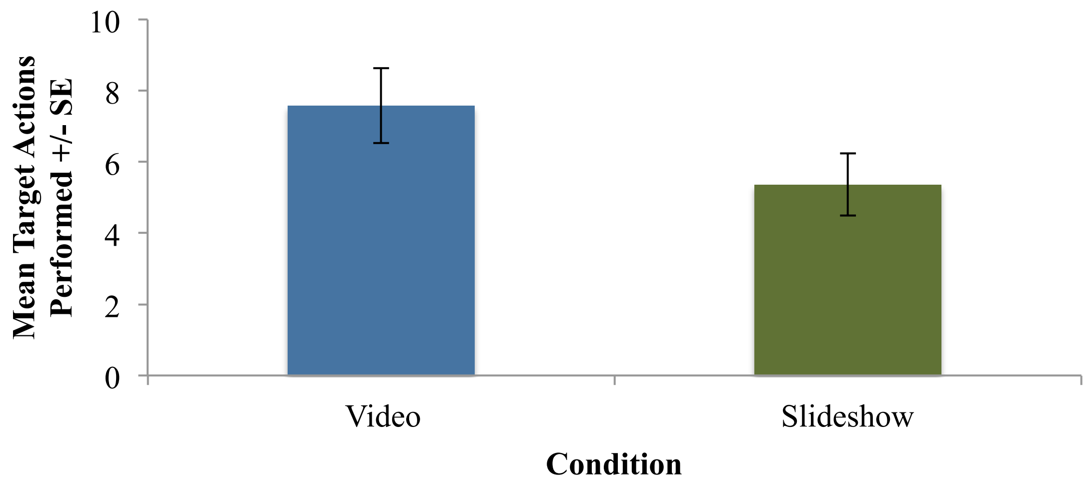


Figure 3. Experiment 2: Mean Production of Target Actions Across Conditions.

Table 9

Experiment 2: Production of Target Actions by Toy and Condition

	Video M (SD)	Slideshow M (SD)
Lego* *(6 possible actions)*	2.88 (2.54)	1.91(2.04)
Light *(5 possible actions)*	1.09 (1.39)	0.84 (1.11)
Pasta** *(5 possible actions)*	2.89 (1.38)	1.78 (1.18)
Sorting *(1 possible action)*	0.72 (0.42)	0.70 (0.44)
Overall	7.58 (4.45)	5.36 (3.70)

** $p < 0.05$, * $p < 0.10$

Verbal memory for each toy. In terms of children's verbal memory for the actions performed on each toy (see Table 10), the univariate test was not significant for the Lego man ($F(1,58) = 0.90$, $p = 0.35$), Playdough pasta maker ($F(1,58) = 0.01$, $p = 0.93$) or sorting toy ($F(1,58) = 0.74$, $p = 0.40$), but was marginally significant for the light machine ($F(1,58) = 3.12$, $p = 0.08$), suggesting that verbal memory was slightly higher in the video condition than in the slideshow condition in just the case of the light machine.

Table 10

Experiment 2: Verbal Memory Score by Toy and Condition

	Video M (SD)	Slideshow M (SD)
Lego	2.09 (0.82)	2.19 (0.82)
Light*	2.16 (0.72)	1.75 (0.88)
Pasta	2.13 (0.87)	2.13 (0.71)
Sorting	2.00 (1.02)	2.16 (0.85)
Overall	8.37 (2.28)	8.19 (2.16)

* $p < 0.10$

Attention to the demonstration of each toy. As for children's attention to the demonstration for each toy (see Table 11), the univariate test did not reach significance for the Lego man ($F(1,58) = 0.001$, $p = 0.98$), light machine ($F(1,58) = 0.45$, $p = .51$) or sorting toy ($F(1,58) = 0.002$, $p = 0.96$). The univariate test for the Playdough pasta maker did reach significance, supporting higher attention in the video condition than in the slideshow condition ($F(1,58) = 4.18$, $p < 0.05$).

Even more than in Experiment 1, it should be noted that attention was at ceiling in Experiment 2, with all means well above 90%. Interestingly, an independent samples t-test with proportion of time spent attending as the dependent measure and age group as the grouping variable suggested that 5-year-old children attended for a longer proportion of the time (*M* = 0.99, *SD* = 0.02) than 3-year-old children (*M* = 0.96, *SD* = 0.04, $t(62) = -2.86$, $p < 0.01$). However, both age groups appeared to have remarkably high attention to the demonstration. Three-year-old children ranged from 83% to 100% on the individual level while 5-year-old children ranged from 93% to 100%.

Table 11

Experiment 2: Proportion of Time Attending During the Demonstration by Toy and Condition

	Video M (SD)	Slideshow M (SD)
Lego	0.98 (0.05)	0.97 (0.05)
Light	0.98 (0.04)	0.97 (0.07)
Pasta*	0.99 (0.02)	0.97 (0.04)
Sort	0.97 (0.06)	0.97 (0.07)
Overall	0.98 (0.02)	0.97 (0.04)

* $p < 0.05$

Developmental differences. In order to determine if the reported findings differed based on the age of the child, the preceding MANCOVA analysis was rerun with age group entered as a fixed factor instead of age in months being included as a covariate. There were no significant differences in performance on the dependent measures across the two age groups (Wilks' $\wedge = 0.53$, $F(13,46) = 3.24$, $p = 0.002$), suggesting that the 3-year-old and 5-year-old children performed similarly on these tasks.

In contrast, the univariate tests pointed to the 5-year-old children having the upper hand in terms of reproducing the target actions on the Playdough pasta maker ($M = 3.02$, $SD = 1.49$) when compared to the 3-year-old children ($M = 1.66$, $SD = 0.87$, $F(1,58) = 5.76$, $p = 0.02$). The 5-year-old children also did better at the sorting task ($M = 0.94$, $SD = 0.25$) than the 3-year-old children ($M = 0.48$, $SD = 0.45$, $F(1,58) = 5.43$, $p < 0.03$). Lastly, the 5-year-old children attended more during the demonstration of the sorting task ($M = 0.99$, $SD = 0.02$) when compared to the 3-year-old children ($M = 0.95$, $SD = 0.08$, $F(1,58) = 8.62$, $p < 0.01$), though attention for both groups was still markedly high. The univariate tests on the other 9 dependent measures did not reach significance (p's > 0.05). These findings point to the 5-year-old children performing somewhat better than the 3-year-old children, but only significantly so on a few of the measures.

Given these minor age differences, it seemed of interest to rerun the MANCOVA separately for the two age groups. Interestingly, this pair of analyses suggested that 5-year-old children were driving the aforementioned condition differences in production of target actions on the Playdough pasta maker ($F(1,27) = 12.68$, $p = 0.001$) and marginally on the Lego man ($F(1,27) =2.95$, $p < 0.10$). Though trending in the same direction in terms of number of actions performed, none of the univariate tests reached significance when only considering the 3-year-old children (p's > 0.05).

Individual Difference Measures

Another question of interest was whether individual differences affected children's learning. As in the first experiment, partial correlations were conducted between the three primary dependent measures (production of target actions, verbal memory score, proportion of time spent attending to the demonstration) and the individual difference measures (CSUS, CBQ, PPVT-4, Inhibitory Control, Computer Survey) while controlling for age (all) and verbal ability (for CSUS and Executive Function). A Bonferroni correction was also applied within each individual difference measure, to account for the numerous correlations conducted.

Theory of mind: CSUS. Twenty-one partial correlations were conducted relating each of the 7 CSUS measures to the 3 performance measures, with a required p-value of 0.002 or lower to reach significance after the Bonferroni correction. When correlating the CSUS total score and the CSUS subscale scores to the three performance measures, no correlations reached significance either in the whole sample or within each condition (*p*'s > 0.002).

Temperament: CBQ. Forty-five partial correlations were conducted relating each of the 15 CBQ scales to the 3 performance measures, with a required p-value of 0.001 or lower to reach significance after the Bonferroni correction. Partial correlations (controlling for age) between the subscale scores on the CBQ and children's production of target behaviors and memory for action evealed no correlations reached significance either in the whole sample or within each condition (*p*'s > 0.001).

Verbal ability: PPVT-4. Three partial correlations were conducted relating PPVT-4 score to the 3 performance measures, with a required p-value of 0.017 or lower to reach significance after the Bonferroni correction Partial correlations (controlling for age) between score on the PPVT-4 and children's production of target actions, verbal memory score, and proportion of time attending to the demonstration showed significant positive relations between verbal ability and children's production of target actions and verbal memory score (see Table 12). I also looked at partial correlations within each condition, though these were less powerful analyses given only 32 children per condition. Still, indications of a positive relation remained. There were no significant relations between PPVT-4 score and children's proportion of time attending to the demonstration (p's > 0.017).

Table 12

Experiment 2: Correlations Between Verbal Ability and Performance Measures

	Overall	Video	Slideshow
Target Actions	0.33**	0.25	0.36*
Verbal Memory	0.40**	0.48**	0.34[a]

** $p < 0.017$, * $p \leq 0.05$, [a] $p = 0.06$

Inhibitory control: Day/night, grass/snow, gift delay. Fifteen partial correlations were conducted relating the 5 inhibitory control measures to the 3 performance measures, with a required p-value of 0.003 or lower to reach significance after the Bonferroni correction. Partial correlations (controlling for age in months and verbal ability) between the scores on the three inhibitory control measures (day/night task, grass/snow task, and gift delay task) and children's production of target actions, verbal memory score, and proportion of time attending to the demonstration revealed no significant correlations when looking at the sample as a whole (p's > 0.003). When looking within the conditions, there was a negative relation between time until first peak and proportion of time attending to the demonstration in the slideshow condition (r =

-0.61, $p < 0.001$). Similarly, in the video condition, there was a negative relation between number of peaks in the gift delay task and proportion of time spent attending ($r = -0.58$, $p = 0.001$). However, considering that attention was near ceiling in both conditions, these correlations do not seem particularly meaningful.

Computer survey. Twenty-seven partial correlations were conducted relating the 9 computer survey measures to the 3 performance measures, with a required p-value of 0.002 or lower to reach significance after the Bonferroni correction. Partial correlations (controlling for age) were conducted between the measures on the computer survey and the three dependent measures of main interest (production of target actions, memory score, proportion of time spent attending to the demonstration). No correlations reached significance when looking at children overall or within conditions (p's > 0.002).

Predicting Successful Production and Memory

A remaining question of interest was what specific measures predicted children's performance; in other words, what significantly predicted children's successful production of target actions and verbal memory? To answer this question, a stepwise multiple regression was conducted first on target actions and second on children's verbal memory score. In step 1, the predictors were age in months, PPVT-4 score, CSUS total score, and inhibitory control composite. These predictors were entered in first so that they were controlled for when looking at the next comparison of interest – condition. In step 2, condition was added as a predictor in order to determine its unique contribution to the model. Lastly, in step 3, several of the computer survey variables were added in as a block (experience with the mouse, years of computer experience, and enjoyment of the computer) since it was of interest if computer experience facilitated performance. This final block was added in order to determine if adding computer-related variables to the model was able to explain any additional variance in children's performance.

For the multiple regression with production of target actions as the dependent measure, model 1 explained a significant 49.1% of the variance in performance ($F(4,59) = 14.23$, $p < 0.001$). Out of the four initial predictors, PPVT-4 score ($t(59) = 2.74$, $p < 0.01$) and age in months ($t(59) = 2.56$, $p < 0.02$) emerged as significant predictors of production of target actions. In step 2, condition was added in as a potential predictor and also emerged as significant ($t(58) = -2.73$, $p < 0.01$). PPVT-4 score ($t(58) = 2.31$, $p < 0.03$) and age in months ($t(58) = 2.73$, $p < 0.01$) remained as significant predictors as well. The new model explained a significant 5.8% more variance, for a total of 54.9% of variance in production of target actions explained ($F(1,58) = 7.44$, $p < 0.01$). In step 3, several of the computer survey variables were added in as a block, but none of these final predictors emerged as significant, and the amount of variance explained by the model changed by a nonsignificant 4.8% ($F(3,55) = 2.17$, $p = 0.10$).

A stepwise multiple regression was also conducted to predict verbal memory performance. The steps were the same as with the multiple regression on production of target actions. In step 1, only PPVT-4 score emerged as a significant predictor of memory ($t(59) = 3.10$, $p < 0.01$). This initial model explained a significant 40.6% of the variance in verbal memory score ($F(4,59) = 10.08$, $p < 0.001$). In step 2, PPVT-4 score remained as the only significant predictor of memory performance ($t(58) = 3.01$, $p < 0.01$) with condition adding 0% to the variance explained ($F(1,58) = 0.003$, $p = 0.96$). Lastly, in step 3, PPVT-4 score still remained as the only significant predictor ($t(55) = 2.73$, $p <$

0.01), with the block of computer variables adding a nonsignificant 0.03% of variance explained ($F(3,55) = 0.10$, $p = 0.96$).

Segmentation of the Slideshow

For the 32 children participating in the slideshow condition, I looked more closely at the data to see if children were using the learning medium to help them segment the action. A paired-samples t-test comparing children's dwell times for slides depicting breakpoints in action versus within-unit slides was not significant ($t(31) = -0.29$, $p = 0.77$).[6] In other words, there was no evidence of segmentation by the children.

In addition, it appeared that (once again) children were advancing through the slideshows very quickly. A MANOVA with duration of demonstration for each toy entered as the dependent measures and condition entered as a fixed factor suggested that duration of the demonstration significantly differed between conditions (Wilks' $\Lambda = 0.66$, $F(4,59) = 7.61$, $p < 0.001$, see Table 13). The mean duration of the demonstration for the slideshow condition was significantly shorter than the mean duration of the demonstration in the video condition for the Lego man ($F(1,62) = 6.11$, $p < 0.02$), light machine ($F(1,62) = 9.12$, $p < 0.02$), Playdough pasta maker ($F(1,62) = 4.42$, $p < 0.05$), and sorting toy ($F(1,62) = 28.80$, $p < 0.01$).

It should be briefly mentioned again that, given these differences in demonstration duration, one might be concerned that condition differences would no longer exist if duration were taken into account. To rule out this possibility, ANCOVAs were conducted on production of target actions for each toy individually with each toy's respective

[6] Paired sample t-tests comparing dwell times to breakpoints and within-unit slides for each of the four toys individually confirmed that children were not segmenting any of the slideshows.

duration controlled. In agreement with the previously presented analyses, the ANCOVA on the Playdough pasta maker revealed that the condition difference remained even when adding in demonstration duration as a covariate ($F(1,57) = 13.26$, $p < 0.001$), while the ANCOVAs on the other 3 toys, when controlling for their respective demonstration duration, did not reach significance (p's > 0.05).

Table 13

Experiment 2: Duration of Demonstration (in Seconds)

	Video M (SD)	Slideshow M (SD)
Lego*	40.36 (2.70)	33.76 (14.89)
Light*	29.09 (1.60)	22.73 (11.82)
Pasta*	31.21 (3.76)	25.88 (13.81)
Sorting*	46.20 (2.15)	32.73 (14.04)

* $p < 0.05$

Discussion

The second experiment suggested mixed findings in terms of how the video and slideshow learning media compared. For two of the four toys, production of target actions was equivalent across the two conditions. For the other two toys, children performed more target actions after viewing a video than after advancing through a slideshow. Unlike Experiment 1, Experiment 2 suggests that, not only is the slideshow no better than the video in promoting learning, but it might even be worse in some cases. In agreement with Experiment 1, children's memory was equivalent between conditions and children's attention to the demonstration was at ceiling.

There was again little of note in terms of relationships between individual difference measures and children's performance. Once again, the only significant relation was a positive correlation between children's performance and verbal ability. Children with higher verbal ability performed with greater success on the verbal memory task and when asked to reproduce the target actions.

The results of the multiple regressions also seem compatible across experiments. In terms of the production of target actions, verbal ability and age were again the major predictors, along with condition in step 2. In both cases, score on the PPVT-4 (a measure of children's verbal ability) predicted children's memory performance. In other words, children with higher verbal ability performed better at the test of verbal memory. This seems sensible, as children were verbally asked questions and were required to provide a verbal response in the memory task.

Furthermore, the slideshow again did not come across as a particularly successful learning medium. Congruent with the first experiment, children showed no evidence of segmentation of the slideshow and again advanced through the slides very quickly in comparison to the duration of the video demonstration. This is in spite of the fact that adults readily segmented all four action sequences in the stimulus verification sample, indicating that the slideshow stimuli themselves were seemingly non-problematic. The fact that children's dwell times failed to show sensitivity to segmental structure across both experiments is a clear non-replication of previous dwell-time research, and as yet the reasons for this non-replication are unclear.

CHAPTER IV

GENERAL DISCUSSION

In this discussion, I will first review the pattern of results among the different learning media compared in this set of experiments and how this fits with various theoretical perspectives on children's learning. I will then discuss why the slideshow in particular may not have been as effective as previously speculated, and I will suggest potential areas for improvement. Next, I will comment on why differences were noted across conditions in production of action but not in children's verbal memory. Following this, I will place these results in a broader context and suggest the implications of this dissertation. I will wrap up by pointing to several limitations to this work, and several potential directions for future research.

Comparing the Learning Media

In Experiment 1, live action superseded the other conditions in helping children learn how to produce the target actions. Learning from the slideshow and video did not differ, but both produced greater learning than when children were not provided with any demonstration at all. In Experiment 2, learning from the slideshow and video was equivalent in the case of two of the four toys, but the slideshow resulted in lower production of target actions for the other two toys. This slight difference in results across experiments could have been due to a variety of factors that differed between the two experiments. For one, the demonstration was changed from a video embedded with pedagogical cues to one without such clear cues. Perhaps having fewer pedagogical cues to rely on made children less likely to notice critical slides in the slideshow (the slides that provided pertinent information about the action sequence). Also, five-year-old children participated in Experiment 2 instead of four-year-old children. In addition, sample size was larger in Experiment 2 (32 in each condition versus 18) and thus analyses were more powerful. Given that raw means in Experiment 1 suggested that the slideshow might have resulted in slightly worse outcomes than the video condition for at least some of the toys, results across studies seem compatible.

Furthermore, though learning media had a distinct impact on children's ability to produce the target actions, learning media did not seem to have an impact on children's verbal memory. In other words, children's verbally reported memory for the event sequences was identical across conditions while their actual production of the target actions varied. This is perhaps not surprising given the different demands of the tasks and noticeably differing degrees of variability shown in children's performance on each of these tasks; I will return to this topic in a subsequent section.

Given the plethora of prior research indicating benefits to live versus video demonstrations for children's learning (Barr & Hayne, 1999; Barr et al., 2007; Hayne et al., 2003; Strouse & Troseth, 2008), the comparable finding in Experiment 1 of this dissertation is sensible and unsurprising. The more interesting question is why the video and slideshow did not differ in their learning outcomes for children, and why the self-paced slideshow might have even led to worse learning outcomes in some cases. At the heart of it, both the video and slideshow are representative of 2-dimensional learning sources. As mentioned in the introduction, a video deficit effect has been noted in a number of studies until around 5 years of age (Flynn & Whiten, 2008; McGuigan, et al., 2007). It is plausible that this deficit extends to other 2-dimensional media like the slideshow. In fact, the video deficit has been found to extend to touchscreens, a presumably similar learning medium. Zack, Barr, Gerhardstein, Dickerson, and Meltzoff (2009) recently used touchscreens with toddlers to test performance between: 3D to 3D, 2D to 2D (both non-transfer), 3D to 2D, and 2D to 3D (both transfer). All groups performed target actions at a rate above baseline, however transfer groups performed significantly fewer actions than the non-transfer groups. Transfer was impaired in both directions – whether going from 2D to 3D or vice versa. Thus, the video deficit effect seems applicable to other, more contemporary, forms of 2-dimensional media including touchscreens and the slideshow utilized in the present set of studies.

Furthermore, as the task at-hand becomes more complex (or as an event sequence to be learned becomes more challenging), it seems possible that the difficulty of transferring what is learned from a 2-dimensional source to a 3-dimensional object might increase. Hayne (2004) has argued that representational flexibility changes across childhood; in other words, successful performance depends on children perceiving as close a match as possible between cues at encoding and cues at retrieval. Thus, perhaps given the age of the children used in the present experiments (3 to 5 years) and the difficulty of the production tasks (several of the toys were quite novel and/or required multiple steps), children's representational flexibility probably was challenged. In order to successfully reproduce the target actions after viewing a demonstration on a 2D source, children would need to maintain a mental representation of the object and the multiple actions performed on it, which can be cognitively taxing at such a young age.

A related theoretical explanation for children's difficulty with this transfer between 2D and 3D sources comes from years of work by Judy DeLoache (DeLoache, 1991; DeLoache & Bruns, 1994; DeLoache, Simcock & Marzolf, 2004). DeLoache

(1991) suggests that children are challenged by dual representation – when a child must simultaneously hold in mind both a representation of the object as a physical object in its own right as well as a symbol for another object. This dual nature of the symbol is challenging for children, as they are often drawn to the physical traits of the symbol as an object in its own right and find it difficult to simultaneously work with the object in its symbolic sense. In relation to the representational flexibility accounted speculated by Hayne (2004), children need to acquire enough experience with symbols in order to understand their representational nature and relate a symbol to reality. Thus, in order to successfully learn from a video (or television) or slideshow (or computers more generally), a child must appreciate how 2D and 3D sources relate, and then act in accordance with that knowledge.

Several other theoretical explanations seem applicable here in relation to children's reduced learning performance with both the video and slideshow relative to live action. Specifically, Prinz (1997) posed a common coding theory, which specifies that children represent action perception and production in a similar manner. Thus, how children encode an action sequence has consequences for their ability to produce that action sequence. If visual features are mismatched between encoding and production (such as from a flat 2D source to a 3D object), then production becomes harder for children. In addition, Barr and Hayne (1999) posit a perceptual impoverishment account, suggesting that 2D perceptual input is impoverished in comparison to 3D input. Transfer of learning becomes more difficult under such conditions. Interestingly, research on toddlers' processing of 2D versus 3D objects has used event-related potentials (ERPs) to show that children process 2D images more slowly than 3D. Their processing patterns seem to suggest that young children recognize 3D objects earlier than 2D objects.

These various theoretical accounts all seem to point to a mismatch between 2D and 3D sources. The perceptual similarities do not align as well between 2D and 3D (as in the video and slideshow conditions presented here) when compared to transferring directly from a 3D to another 3D source (as in the live condition presented here) or even a 2D to a 2D source, as shown by Zack and others (2009). Young children have a fragile representational system, and this transfer is challenging without ample experience. As children become older, their experience with 2D media increases and they become better at recognizing the significance of objects on the screen. The video deficit effect is then reduced.

It should be noted, however, that the video deficit effect might not always be evident. In fact, Troseth and DeLoache (1998) found evidence for a video enhancement effect, where video actually enhanced children's cognitive performance. A group of 2½-year-old children were tasked with using a scale model to make inferences about a hidden toy in a larger room. Children this age have difficulty with this task, which requires coping with dual representations, in that it requires working with the scale model as a symbol for the larger room while also interacting with it as an object in its own right. Interestingly, when 2½-year-old children were shown the hiding event involving the scale model via video rather than via live action, they more readily used it as a symbol to draw inferences about the hidden toy's location in the larger room. In this case, it appeared that having the scale model present in a 2D format reduced its salience in terms of being an object in its own right, thereby enabling children to focus more readily on it as a symbol. In the present dissertation, in contrast, children were faced with learning from the video or slide-show how interact with real objects, and thus reducing the salience of the objects involved as objects in their own right via video or slideshow would have been disadvantageous for children's ultimate success in the memory tasks, rather than beneficial. In sum, the current findings seem consistent with prior findings that video reduces the salience of objects for children, which under some circumstances (e.g., the scale model task) can have cognitive benefits, whereas under other circumstances (e.g., learning new event sequences with the objects displayed, as in the present dissertation) undercuts learning

Developmental Differences in the Learning Media

The literature has consistently pointed to the video deficit effect fading away around age 5 (Flynn & Whiten, 2008), but remaining prominent throughout infancy and the preschool years (Barr, 2010). The current results are generally in line with these findings. In the first experiment with 3- and 4-year-old children, findings were identical for both age groups; learning from live action was superior to learning from 2D sources in terms of children's production of target actions. A video deficit effect was clearly evident. In the second experiment, I included 5-year-old children as it seemed plausible that they might perform better on the self-paced slideshow when compared to the younger children, since the video deficit should be significantly reduced by that age (Flynn & Whiten, 2008). However, both 3-year-old and 5-year-old children seemed to perform better following a video demonstration when compared to a self-paced slideshow demonstration, but it should be noted that this finding only reached significance for the 5-year-old children, perhaps due to greater variance in their performance (the 3-year-old children simply did not perform as many actions). Though I cannot speculate on the video deficit effect in the second experiment given that there was no live action condition, there did seem to be a “self-paced slideshow” deficit effect somewhat evident in children’s production of the target actions.

These findings also beg the question of what results we might see in an older group of children – potentially 6- or 7-year-old children who are hypothesized to be developmentally beyond this video deficit effect. If the video deficit effect has truly disappeared by that point, I would hypothesize that their video learning would be equivalent to their live action learning. However, given that the 5-year-old children in the second experiment showed better performance following the video demonstration than the self-paced slideshow demonstration, I might hypothesize that the older children would also perform better after a video than a self-paced slideshow. Other aspects characteristic of the self-paced slideshow, such as having to split attention between the screen and mouse and having to fill in missing frames of information as you advance through the slideshow, might yield reduced learning outcomes relative to video demonstration, over-and-above a video deficit effect extending to 2D media more generally.

It seems to make sense based on the preceding theoretical views that the two media would not differ in their impact on learning given that they are both 2-dimensional sources of information. However, the slideshow utilized in the current set of experiments did have several characteristics that were different from the video. Perhaps a mean difference existed because the slideshow condition required children to split attention between their clicking of the mouse and the images on the screen. Or perhaps it was the fact that, given the use of a slideshow design based on a regular extraction rate, the information depicted was substantially reduced relative to the video demonstration. The next section will focus on why the slideshow, despite its seemingly promising self-control component (e.g., Mayer & Chandler, 2001), did not result in any benefits for children over-and-above video, and perhaps even engendered a slight detriment to learning when compared to the video.

The Lack of a Slideshow Benefit, and Perhaps Even a Detriment?

In the introduction, I described the inspiration behind the self-paced slideshow. Generally, our past work (Meyer et al., 2011) suggested that children meaningfully segment slideshows into units, and this segmentation is related to their memory accuracy; in other words, children who successfully segmented the slideshows showed enhanced memory for the actions they had witnessed. As I will detail in this section, patterns of segmentation were not evident in the present experiments, which could indicate that the slideshow medium was not readily processed by children, thus rendering it unhelpful as a learning medium. I will then discuss potential flaws of the slideshow design, any of which could have led to the slideshow being somewhat less useful than a video. I will also suggest potential improvements that could be made to the slideshow to make it a more useful learning medium.

No Segmentation in the Slideshow

Across both studies, children showed no evidence of segmentation in the slideshow condition; that is, they did not display the predicted tendency to dwell longer on breakpoint slides than within-unit slides. These sequences are segmentable, since the adults showed such patterns in the stimulus verification sample mentioned in Experiment

2. Thus, one hypothesis for why children did not show similar segmentation patterns is that these action sequences may simply have been too novel for children to easily segment. In other words, perhaps children had difficulty segmenting these sequences because they had trouble making predictions about what would happen next. The toys utilized in Meyer et al. (2011) could be characterized as infant toys (e.g., stacking rings and nesting cups), thus preschool-aged children were likely highly familiar with those precise sequences before ever viewing the slideshow. In contrast, though children might have been generally aware of how some of the toys in the present experiments functioned (e.g., Legos connect together or Playdough often gets rolled into a ball), that does not mean they could predict the exact sequence of events (e.g., that the biggest Legos went first as the legs, then a short blue connecting piece, then a flat stomach piece, etc.). Perhaps using more familiar toys would result in children's ability to segment; however, if children already knew the action sequences before participating in the experiment, there would be no reason to suspect differences across conditions.

This lack of segmentation-relevant dwell-time patterns may be one reason why the slideshow was not a particularly helpful learning medium. There are numerous additional reasons why the slideshow did not result in learning benefits over the video. For one, the form of self-control instantiated by mouse-clicking may not have been the best option. The numerous potential flaws in the slideshow format utilized in the current study will be addressed next.

The Slideshow: Problems and Suggested Improvements

Even if further research can replicate these results that the slideshow leads to lower learning outcomes than live action and is no better or maybe even worse than video, there would remain the possibility that the slideshow format itself is not properly designed to increase children's learning outcomes in comparison to a video. According to this view, the results reported here simply reflect a failure of this particular slideshow design to elicit learning benefits beyond a video.

There are at least four ways in which this particular slideshow design is problematic. First, the slideshow was self-controlled in the sense that children could advance the slides as whatever pace they saw fit. However, this resulted in children going through the slideshows very quickly in comparison to the live or video demonstrations. Perhaps children's sense of control could be increased, perhaps by allowing them to go both backwards and forwards in the slides and/or allowing them to choose the order in which they saw the event sequences. Such changes would perhaps enhance children's sense of control or engagement with the task, resulting in higher learning outcomes. Attention to the slideshow was somewhat lower than attention to the video and live demonstrations in the first experiment, and thus it is a worthy enterprise to determine a way to make the slideshow a more engaging and interesting medium.

Second, the slideshow in this study represents frames extracted from an unfolding action sequence. Thus, there were essentially pieces of information missing or "blank spaces" that children had to piece together in order to create a smooth flow of action. Perhaps, this omission of whole swaths of information put too high of a cognitive load on children; in other words, there was missing information that needed to be filled in, which would have involved processing effort perhaps beyond children's capabilities, and thus it became harder to learn the action sequences.

Another option would be to have the slideshow broken into grouped segments instead of individual slides, so children could select when to advance to the next segment (perhaps between each "step" of the sequence – e.g., 20 slides would advance automatically on their own, then there would be a pause and children could advance to the next segment). In such a format, slides could potentially be extracted at a higher rate since children would not have to click a button each time – they would just need to be watching the screen. This would fill in some of the gaps of information and make for a smoother progression of the slides. Similarly, in Schaffer and Hannafin (1986) and Zhang et al. (2006), adults advanced through segments of information. Perhaps "grouping" the slides together into meaningful components would be helpful for children, as well as omitting the need to click with each and every slide. The temporal inconsistency of the self-paced slideshow when the child has to click to advance each slide might make it difficult to process in comparison to a set of segments where the user only needs to click occasionally to move on to a new segment. Furthermore, the need to click the mouse with each slide while simultaneously viewing the presentation presents children with a dual challenge that might be quite tasking; I'll return to this notion in a moment.

A third way that the current slideshow design is problematic is that the self-paced slideshow required children to develop some proficiency with the computer mouse. Though Liu (1996) found that only 1 of 12 children in this age range had difficulties learning how to use the mouse, the present study required more vigorous mouse use, in the sense that children had to consistently push the mouse in order to advance the slides. For instance, in Experiment 2, children had to click the mouse over 200 times to get through the shows. A review of the videotapes in the slideshow condition seemed to suggest that, on the instances when children would look away from the computer monitor, it was to look down at their hand, perhaps suggesting that they were "checking up" on their use of the mouse. In the second experiment, of the 32 children in the slideshow condition, 29 had prior experience with a mouse and specifically 10 with a wireless mouse (the type used in the present study). Of children with mouse experience, their experience was rated, on average, only a 2.69 on a 1 to 5 scale with the highest frequency of children scoring a 2 (8 children). Thus, perhaps changing the slideshow format to not include this requirement of mouse proficiency might be beneficial for children of this age. However, it is worth mentioning here that children in both experiments advanced through the slideshows very quickly, indicating that they had little difficulty with the mouse-clicking task; thus, being capable of clicking a mouse may not have been a primary problem with the current design.

One idea for improvement is to have children directly touch the screen in order to advance the slideshow. We have had some success with using a touch pad with infants; infants make contact with the pad in order to advance the slides appearing on the screen (Baldwin et al., in prep; Sage & Baldwin, 2012; Sage et al., 2012). Looking back to the computer survey used in Experiment 2, since 20 children out of 64 had experience with an iPad, and considering that this would ensure that all attentional focus be on the screen, this seems like a worthwhile option. However, Zack et al. (2009) reported that the video deficit effect extended to touchscreens. But, they were not utilizing slideshows in combination with the touchscreen. In fact, children's actual interaction with the touchscreen was quite limited (touching it once produced the demonstrated event). Perhaps using the slideshow in combination with the touchscreen would result in children

(1) having an easier time advancing the slides, and (2) being more engaged with the task since they would essentially be touching the event as it unfolded.

Lastly, it seems like children had to essentially split their attention in the slideshow condition. They needed to (1) attend to and encode the action on the screen, and (2) actively press and maintain clicking of the computer mouse. Perhaps this is too demanding for young learners. Two of the ideas for improvements already mentioned in this section might also be applicable here. First, focusing all of children's attention in one place, such as having them touch the screen instead of a different piece of equipment, might be helpful. Furthermore, a slideshow that advanced automatically as children watched would eliminate this division of attention. The latter format is helpful in that it prevents the need to split attention, but potentially detrimental since it also takes away the self-control component of the slideshow.

Thus, there seems to be room for improvement in slideshow design. Future work should consider these various limitations of the current design, and try to make a slideshow that is perhaps more engaging while also reducing the need to click a mouse so often.

With all this discussion of the slideshow resulting in equivalent (or even poorer) learning in comparison to video, it is worth again mentioning that only differences in production of target actions were found. In terms of verbal memory, children performed equally across the live action, slideshow, and video conditions. In the next section, I will speculate on why differences were noted in production but not in memory across these three learning media in the present set of experiments.

Why Effects in Production and No Effects in Memory?

Studies examining the effects of different media on children's learning have typically focused on imitation tasks (e.g., Barr & Hayne, 1999; Hayne et al., 2003; Strouse & Troseth, 2008). The present set of experiments added an additional component – children's verbal memory for the events they had witnessed. In line with prior studies, condition differences were evident in children's production of target actions (e.g., Hayne, et al., 2003). However, verbal memory was strikingly equivalent across conditions despite the differences noticed in production of action. The remaining question then is, why?

One possibility is that the production tasks were tapping into recall memory while the verbal memory tasks were tapping into recognition memory. Recognition is known to be a simpler task than recall across the ages (Hogan & Kintsch, 1971). Recognition makes use of context. In the case of the present study, children were asked questions about the events they had witnessed with retrieval cues embedded into the questions (for instance, "what did the machine do?" prompts children that the light machine does something in particular; "what color was the last block, the one on the very top?" prompts children to remember that there were numerous blocks and they need to report the color of the last one put into place). If children reached the point of the actual prompt (e.g., "was it red or yellow?"), they had the additional information of choosing amongst the correct item or a distractor item. In contrast, when faced with the challenge of producing the target actions, children were asked to do what the woman did in the show. The pieces were placed in front of children, and then children had to determine what to do next. It is possible that some of the pieces acted as contextual clues for children, however children were not given a specific verbal directive like “make the machine work!” or “how did those Legos go together?”, so producing the target actions seemed a more challenging task than being asked (with verbal cues) about the actions.

Also, it is possible that giving children all imitation tasks prior to having the verbal memory task helped children to perform better on the memory task than on the imitation task. In essence, children could tap into their memory from both watching the demonstration and manipulating the objects. Against this, however, children often correctly answered memory questions without performing the corresponding action during the imitation task. Similarly, they did not perform any differently in the subsequent teaching task than in the imitation task. Thus, their production of action and verbal report of the action seemed to be somewhat unconnected; in other words, it was not uncommon that a child could answer questions correctly (e.g., “Made a light come on! Put the blocks in order! Yellow on top!”), and then fail to perform any of the target actions on that toy. For instance, in Experiment 1, 14 children (26%) either scored perfectly on the memory test or inaccurately answered just 1 of the questions about the light machine while also failing to perform any of the target actions on the toy. Likewise, in Experiment 2, 22 children (30.5%) either scored perfectly on the memory test or inaccurately answered just 1 of the questions, but also failed to perform any target actions on the light machine. This illustrates that high memory accuracy for a given toy was possible despite a complete lack of reproduction of the target actions on that same toy.

Another possibility is that the memory questions were easy and resulted in a restricted range, with the resultant lack of variability undercutting any relationships that might actually hold between this task and the different learning media. There was some variability in memory score – out of a possible 18, the range in the first experiment was 5 to 18. However, only 6 out of the 54 children scored 9 or lower (half or less correct). Thus, most children were scoring in the upper half. Similarly in Experiment 2, the range was 2 to 12 out of a possible 12, with only 14 out of 64 children scoring 6 or lower (half or less correct). Thus again, most children were scoring in the upper half. The mean in both cases was around 70-75% correct and numerous children did produce perfect scores, again indicating that children were generally doing quite well. In contrast, children showed much higher variability in the imitation task and no child performed all target actions (26 actions in Experiment 1, 17 actions in Experiment 2). In Experiment 1, scores ranged from 0 to 21 with an interquartile range of 4 to 15. Similarly in Experiment 2, scores ranged from 1 to 15 with an interquartile range of 3 to 10. Means in both instances were around 30-35% of target actions performed. Given these statistics, it seems clearly evident that the verbal memory task was easier for children than the production tasks, and that verbal memory was practically at ceiling levels. It is thus perhaps the case that condition differences were noted in the case of production of target actions given the higher difficulty there when compared to the verbal memory questions. Ultimately, it seems safe to conclude that children performed well at the verbal memory task because it was a simpler and more straightforward task than the production tasks.

Broader Implications for Knowledge Acquisition

Given the prevalence of computers (and other 2-dimensional media such as videos) in the home and school, it seemed a worthy endeavor to discover how one type of computer program – the self-paced slideshow – might fit into the broader picture of learning media. The current dissertation suggests that the video deficit effect extends to the self-paced slideshow, which is perhaps consistent with recent work showing that contemporary 2D media like touchscreens are also a part of this deficit (Zack et al., 2009). This should give parents and teachers pause when determining what type of learning media to use with children, as 3D may, in most cases, supersede 2D. Three-dimensional learning seems to facilitate children in transferring their newfound knowledge to real objects. Though this may become easier with age, it may be the safer bet to continue to teach children with live social interaction until they become proficient with a variety of 2-dimensional media.

Generally, it seems as if 2-dimensional media place high demands on the child learner, in terms of perceptual and symbolic processing. Encoding information in one form and having to reenact it in another form may be challenging for children. As discussed earlier, there are numerous theoretical views for why this might be – including the perspectives put forth by theories of representational flexibility (Hayne, 2009), symbolic representation (DeLoache, 1991), common coding theory (Prinz, 1997), and perceptual impoverishment (Barr & Hayne, 1999). These accounts all purport that the nature of 2-dimensional media makes it difficult for young children to relate what they are seeing to the real world.

An important implication of this dissertation and the relevant theoretical views is that we recognize the importance of social interaction and contingency. At the start of this dissertation, I reported that humans are unique in our use of social information and our ability to readily engage with social partners (Baldwin & Moses, 2001; Gergely & Csibra, 2009; Tomasello, 1999). Given the results of this dissertation, it seems appropriate to reaffirm that sentiment here as we again see that live action supersedes other forms of learning. It ultimately seems that learning from others is indeed a very important means of acquiring knowledge for the young learner. Adults act as critical (and irreplaceable) sources of knowledge. According to the view of Gergely and Csibra (2005; 2006), learning from others places children into the "pedagogical learning stance" where they are primed to learn new information that they can generalize to other scenarios. Perhaps this stance is only available when other humans engage children directly, and is not as readily inducible in children when 2-dimensional forms of learning media are utilized.

To this end, it is not impossible to have social information in 2-dimensional sources. It seems plausible that video and computer-based demonstrations can provide some social information, albeit diminished in comparison to a live source. For instance, an adult might set up a video with a pedagogical context or create a very teaching-oriented video that talks to children. However, these 2-dimensional sources rarely provide any social contingency for children. There is an abundance of research with preschoolers confirming that non-contingent sources of information, like the television, consistently result in reduced comprehension of information (e.g., Calvert et al., 2005; Hayne et al., 2003; Nielsen et al., 2008). As mentioned earlier though, videos can be socially contingent (or responsive to the child) and such adjustments lead to higher learning in comparison to non-contingent videos (Nielsen et al., 2008). This is one means we might take to circumvent the need to always have a live model. It is worthy of note, though, that a live model may be subtlety providing contingent cues to children not possible in even a contingent video. For instance, if a live demonstrator notices a confused look on a child's face, it is possible that they might slow down their actions (even if unknowingly) as a response to the child's silent plea for more information. It is also posited that children tend to imitate more precisely after live demonstrations than other types of demonstrations as a means to continue or lengthen a social interaction (Nielsen et al., 2008; Strouse & Troseth, 2008). Again, even with a contingent video, there is likely not the same sense of being someone's social partner. As mentioned earlier, children also place trust in interactive social sources that they do not place in less social sources (Koenig & Echols, 2003), and they seek out knowledgeable over ignorant adults (Koenig & Harris, 2005). Thus, children might be attributing characteristics (like trust) to social partners that they do not attribute to other sources of information. Thus, even if we embed a video with some social content, it seems plausible that 2-dimensional sources will have a hard time providing as rich of a learning experience as live sources.

Ultimately, the knowledge children gain from other humans is irreplaceable. When children interact with other people, they often seek out information about their environment (Baldwin & Moses, 1996; Gergely & Csibra, 2005; 2009). The same cannot be said every time a child turns on the computer or television. Though future research into the computer as a learning medium is undoubtedly merited, it should be looked at as a potential addition to (not a replacement for) children's learning from other people. The computer does, however, seem to have the potential to provide contingency and interaction not before possible with the television. To justify this, one merely needs to think of all the applications now available on the iPad or iPhone that children are currently engaging with in our modern society. This is an area ripe for research, and it is my hope that other developmental psychologists also take up the cause of seeing how the computer might be transformed into a helpful learning medium for children.

Limitations and Future Directions

This dissertation has verified that live action supersedes 2-dimensional sources in learning outcomes, and that this video deficit effect extends to the self-paced slideshow as well. It has also uncovered that learning to produce action by viewing a slideshow might even result in worse learning outcomes than the video. This discovery, however, is only the tip of the iceberg in understanding how the computer might play a role in children's knowledge acquisition, as many other types of computer programs seem plausible for use with children.

One limitation of the current research was the use of slideshows. This is just one potential computer program that could be used as a learning medium for children. It might not be optimal since it is concise and thus omits information. The major trade-off between the video and slideshow in this study is in pace versus information. The slideshow was self-controlled but provided limited (concise) information since frames of action were essentially missing. The video was not self-controlled but had full and complete information. Children seemed to learn roughly equivalently from these two 2D learning media with the video sometimes being superior, but perhaps a different type of computer program might result in superior learning to the video. Future work should investigate other types of computer programs and how they fit in to the bigger picture of learning media.

Another limitation is that the current work only applies to how slideshows might facilitate learning in 3- to 5-year-old children. The preschool years might be too young for successful use of computer technology as a learning medium, thus what if we applied this medium in an elementary school? At that point, the video deficit effect should have waned such that learning from a video would be more in line with learning from live action (Flynn & Whiten, 2008). A future direction is thus seeing at what age slideshows become helpful, since they seem to be helpful in adulthood. For instance, Mayer and Chandler (2001) confirmed their usefulness in a college population when compared to video learning. A worthwhile endeavor may lie in determining when this transition occurs. In other words, when do children begin to benefit from learning from slideshows (and the computer more broadly) over-and-above video? There may be some evidence for children in later elementary school learning well from slideshows (Boucheix & Guigard, 2005), but a lack of evidence for younger children.

Conclusions

This dissertation deepens our understanding of children's knowledge acquisition, in terms of reaffirming the importance of live, social input provided to children. Findings here confirm that children learn better from live demonstrations over other 2-dimensional sources of information – including both video and computer input. It is perhaps the case that transfer from a 2D source to a 3D object is a challenging task for children in this age group, and that this extends to both continuous video and frame-by-frame slideshow demonstrations.

Remaining topics for future research include discovering why the slideshow here was not a particularly effective learning medium despite the opportunity it provided for children to control the pace, as well as if (and how) other computer programs might result in superior learning outcomes for this age range. Furthermore, if the computer is not an effective medium with this age group, it seems worthy to discover at what age the computer becomes an effective medium. Given the prevalence of computers in most homes and schools in our modern society, this is undoubtedly a worthy focus for future work.

APPENDIX A

MEMORY QUESTIONS

**Correct answers underlined.*

Ghost

1. What did I make? *(Pause)* A cat or a ghost?
2. What did I do with ball? *(Pause)* Stick it on top of the felt or put it below the felt?
3. What pattern was the ribbon on the top of his head? *(Pause)* Striped or polka dot?

Lego Man

1. What did I make out of Legos? *(Pause)* A man or building?
2. What did I do with the Legos? *(Pause)* Stack them up tall or lay them out flat?
3. What color Legos did I use first? *(Pause)* Blue or yellow?

Light Machine

1. What did the machine do? *(Pause)* Make a light turn on or make a noise?
2. What did I do with the blocks? *(Pause)* Put them in some holes or tie them all together?
3. What color was the last block, the one on the very top? *(Pause)* Red or yellow?

Playdough Pasta Maker

1. What did I make with the Playdough? *(Pause)* Spaghetti or vegetables?
2. What did I do right before the spaghetti came out? *(Pause)* Did I press one button or push down two arms?
3. What color bowl did I make the spaghetti in? *(Pause)* Green or purple?

Sorting Task

1. What things did I put into the bowls? *(Pause)* Pencils or crayons?
2. How did I group the crayons and erasers? *(Pause)* By color or object?
3. Which did I pick up first? *(Pause)* An eraser or crayon?

Trap-Tube Apparatus

1. What did I use to get the toy out of the tube? *(Pause)* A string or a stick?
2. What did I do with the stick? *(Pause)* Bang the stick on the hole or put the stick inside the hole?
3. What color was the hole I put the stick in? *(Pause)* Yellow or blue?

APPENDIX B

EXPERIMENT 2: COMPUTER USE SURVEY

COMPUTER SURVEY

Please answer the following questions on the front and back of this sheet, pertaining to your child and computers.

1. Does your child have access to a computer? Yes / No

2. How many computers are in your home? ________

    a. Does your child use a laptop computer? Yes / No

    b. Does your child use a desktop computer? Yes / No

3. At what age did your child first use a computer? _________

4. How many hours a day ***on average*** does your child use a computer? ________

5. How many hours a week ***on average*** does your child use a computer? ________

6. What purpose does your child use a computer for? (Check all that apply)

    - ☐ Educational games
    - ☐ Non-educational games
    - ☐ Drawing
    - ☐ Internet browsing
    - ☐ Movie/video watching
    - ☐ Other *(please specify):* ____

7. How experienced is your child with a computer mouse on a scale of 1-5? _______
(1=never uses, 3=somewhat experienced, 5=expert mouse user).

    a. Does your child primarily use a:
        - ☐ Wired mouse
        - ☐ Wireless mouse
        - ☐ Laptop touchpad mouse

8. Does your child know how to turn a computer on and off? Yes / No

9. How much does your child enjoy the computer on a scale of 1-5? _______
(1=does not enjoy, 3=somewhat enjoys, 5=enjoys very much)

10. What is the **most common** form of supervision of your child when (s)he uses a computer? Please rank the following 1 (most common) to 3 (least common).

- ☐ Adult visually monitors zone where computer is used
- ☐ Adult is beside child as (s)he uses the computer
- ☐ Child uses computers independently

11. What forms of technology does your child regularly use? (Check all that apply)

- ☐ iPad
- ☐ cell phone (for calling)
- ☐ cell phone (for applications/games like the iPhone or Android)
- ☐ laptop computer
- ☐ desktop computer
- ☐ handheld video games
- ☐ game consoles (X-box/Wii/Playstation)
- ☐ television
- ☐ DVD player
- ☐ Other *(please specify):*

  ____

12. Does your child know how to put in and play a DVD/video on: (Check all that apply)

- ☐ A desktop computer?
- ☐ A laptop computer?
- ☐ A DVD player?
- ☐ A game console?
- ☐ Other *(please specify):*

  ____

13. How many hours a day ***on average*** does your child have screen time? ________

    Screen time includes all forms of technology involving a screen – computers, television, handheld videogame devices, etc.

14. How many hours a week ***on average*** does your child have screen time? ________

    Screen times include all forms of technology involving a screen – computers, television, handheld videogame devices, etc.

15. Any additional comments on your child's computer (or related technology) use or enjoyment?

____

____

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