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LEARNING FROM A SCREEN: CAN INTERACTIVE DEVICES IMPROVE CHILDREN'S MEMORY FOR SYMBOLIC MEDIA REPRESENTATIONS?

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Elizabeth Moore

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Signature	Type Name	Date
Ellyn Sheffield Chairperson, Thesis Committee Signature	Ellyn Sheffield Type Name	6-11-14 Date
Committee Member Signature	MICHAL BALASS Type Name	6/11/14 Date
Committee Member Signature	Kerri Goodwin Type Name	6/11/14 Date
Committee Member Signature	Type Name	Date
Committee Member Signature	Type Name	Date
Janet V DeLany Dean of Graduate Studies	Janet V. DeLany Type Name	8/11/14 Date

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Abstract

LEARNING FROM A SCREEN: CAN INTERACTIVE DEVICES IMPROVE CHILDREN'S MEMORY FOR SYMBOLIC MEDIA REPRESENTATIONS?

Elizabeth Moore

This study measured 30- (*n* = 16) and 36-month-olds' (*n* = 29) recall for events viewed live with toys and on a computer tablet. During the presentation session, children viewed four stories - two with toys and two on a tablet. In addition, children actively participated or passively watched the stories during the presentation session. One week later, children were asked to imitate the targets from each of the stories, first in the same dimension as the original presentation and then in a different dimension. We found that children recalled more information when the presentation sessions and imitation tests occurred in the same dimensions than in different dimensions. We found age and gender differences with older children and girls recalling more information than younger children and boys. Finally, we found that children showed a preference for action information over object or location information.

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Introduction

Children's interactions with representational media, such as TV, videos, and computer games have become increasingly prevalent in the last three decades with the advent of computers, cell phones, and computer tablets (DeLoache & Chiong, 2009). According to a survey conducted in 2006 by the Kaiser Family Foundation, children between the ages of six months and six years spend an average of two hours per day exposed to screen media. Furthermore, the average age of introduction to screen media is 6 to 9 months, whereas in the 1970s, the age of introduction to screen media did not occur until about 2.5 years (DeLoache & Chiong, 2009; Lauricella, Pempek, Barr, & Calvert, 2010).

In the 1990s, baby videos and child-directed television shows, such as *Baby Einstein* and *Sesame Street*, became increasingly popular with advertised promises of improving young children's learning in areas such as language development, spelling, and reading (DeLoache & Chiong, 2009; Lauricella et al., 2010; Strouse & Troseth, 2008; Zack, Barr, Gerhardstein, Dickerson, & Meltzoff, 2009;). More recently, interactive computer tablets specifically designed for toddlers (e.g., Leapfrog LeapPad) have appeared on the market, also claiming to enhance learning in young children (DeLoache & Chiong, 2009; Zack et al., 2009). With the increasing popularity and usage of media to teach young children, it is important to examine how children learn from representational media (e.g., video, computer). It is also important to understand the factors that affect children as they mature in order to ensure that learning is optimized.

Therefore, this paper will review the literature examining the research on how young children learn from representational media during the first three years of life as well as the leading theories that help to explain children's deficits in learning from representational media. Based on the literature, the current study examined whether touch-screen devices could improve children's memory for events learned on representational media in attempt to expand the literature and provide more insight into how best to teach children using representational media.

Symbols: A Tool For Learning

Symbols play an important role in children's learning throughout life and are used in various ways to teach children new skills and information (Uttal, O'Doherty, Newland, Hand, & DeLoache, 2009). For example, letters are symbols used in reading. In order to use these symbols correctly, one must understand the relationship between the symbols and their referents. Symbols (e.g., photos of objects, letters of the alphabet, three-dimensional representations, etc.) are entities within themselves, but they also convey important information about their *referents* – something other than themselves (Barr, Muentener, & Garcia, 2007; DeLoache & Chiong, 2009; DeLoache, Uttal, Pierroutsakos, 1998; Deocampo & Hudson, 2005; Strouse & Troseth, 2008; Uttal et al., 2009).

Symbols play an important role in children's ability to learn from representational media, such as TVs and computers. In order to learn from representational media, children must understand symbolic *media* representations, which require understanding the relationship that exists between the two-dimensional (2-D) images presented on representational media and the three-dimensional (3-D) referents (Barr, Muentener, & Garcia, 2007; DeLoache & Chiong, 2009; DeLoache, Uttal, Pierroutsakos, 1998;

Deocampo & Hudson, 2005; Strouse & Troseth, 2008). For example, a bowl of popcorn on TV (2-D) does not share the same physical characteristics as a bowl of popcorn in real life (3-D), but does share a representational relationship.

Assessing Memory and Understanding

In order to measure children's use of and memory for symbolic media representations, three paradigms have been consistently utilized: (a) immediate imitation tasks, (b) deferred imitation tasks, and (c) object retrieval tasks. In immediate imitation tasks, children view a demonstration of an action (e.g., assembling a toy rattle) and then are asked to imitate the actions presented. In deferred imitation tasks, children view a demonstration of an action but are not asked to imitate the actions until after a delay, which could be minutes, days, or weeks (Barr, McIntyre, & Simcock, 2012; Barr et al., 2007; Bauer, Wiebe, Carver, Waters, & Nelson, 2003; Brito, DeLoache & Chiong, 2009; Meltzoff, 1988a; Meltzoff 1988b). Researchers have used these imitation tasks to measure children's ability to imitate actions presented by way of pictures (Bauer et al., 2003; Barr, McIntyre, & Simcock, 2012; Brito et al., 2012; Simcock & DeLoache, 2008) and videos (Barr et al., 2007; Brito et al., 2012; Deocampo & Hudson, 2005; Hayne, Herbert, & Simcock, 2003; Troseth, Saylor, & Archer, 2006; Zack et al., 2009), with the notion that if children possess an understanding of symbolic media representations, they should be able to successfully imitate actions using 3-D objects that were originally presented on 2-D displays.

In object retrieval tasks, children are shown a scale-model of a room and its referent, a large room that is an exact replica of the scale-model. In this paradigm, the experimenter hides a miniature version of an object (e.g., stuffed Snoopy dog) in the scale-model room and then instructs the child to find the life-size object that is hidden in the larger room, located in the same hiding place as in the scale-model (DeLoache & Chiong, 2009). After searching for the object in the larger room, the child is asked to find the miniature object hidden in the scale-model. If a child has a developed understanding of symbolic representation, the child understands that the scale-model maps the location of the hidden toy in the larger room (DeLoache et al., 1998; Strouse & Troseth, 2008; DeLoache & Chiong, 2009; Deocampo & Hudson, 2005).

Object retrieval tasks can also measure children's use of symbolic media representations in the paradigm known as the video-object retrieval task (DeLoache & Chiong, 2009; Troseth & DeLoache, 1998; Deocampo & Hudson, 2005 Lauricella et al., 2010). In this paradigm, the child watches the experimenter hide a toy in a room through a video monitor, and is then asked to go into the room to retrieve the hidden toy. If an understanding of symbolic media representations exists, the child should successfully find the hidden toy after watching through the video monitor. That is, the child can use the representational medium (i.e., video) as a source of information to find the hidden toy.

Using these paradigms, researchers have found learning deficits in children's understanding when learning from scale-models (DeLoache et al., 1998; Deocampo & Hudson, 2005; DeLoache & Chiong, 2009), pictures (Simcock & DeLoache, 2008; Bauer et al., 2003; Brito et al., 2012), and videos (Lauricella et al., 2010; Strouse & Troseth, 2008; Troseth & DeLoache, 1998; Zack et al., 2009; Barr et al., 2007; Hayne et al., 2003). Barr, Muentener, and Garcia (2007) found that 15-month-old children imitated significantly fewer target actions when demonstrated on a video than when shown in a live demonstration. This specific deficit has been termed the *video deficit effect,* in which children learn better from a live demonstration than from a video or picture demonstration. This deficit is thought to be a direct result of children’s underdeveloped understanding of symbolic media representations. (Luricella et al, 2010; Strouse & Troseth, 2008; Barr et al., 2007; Zack et al, 2009; Troseth & DeLoache, 1998; Troseth et al., 2006; Barr & Wyss, 2008; Brito et al., 2012; Hayne et al., 2003; Sheffield & Hudson, 2006). However, the video deficit effect diminishes around the third year, as children learn that symbols can convey important information about their referents (DeLoache & Chiong, 2009; Meltzoff, 1998b; Claxton, 2011; DeLoache, et al., 1998; Barr et al., 2007; Deocampo & Hudson, 2005; Hayne et al., 2003).

Children’s inability to use representational media as a source of information has been explained by two hypotheses: The dual-representation hypothesis and the perceptual impoverishment theory. These two theories propose different developmental trajectories to children’s understanding and usage of symbolic media representations through the first three years of life (Troseth & DeLoache, 1998; DeLoache & Chiong, 2009; Strouse & Troseth, 2008; Claxton, 2011; DeLoache et al., 1998; Richert, Robb, & Smith, 2011; Bauer et al., 2012; Hayne et al., 2003; Simcock & DeLoache, 2008; Troseth et al., 2006).

Dual-Representation Hypothesis

The dual-representation hypothesis emphasizes that infants and toddlers do not understand that an object is an entity in itself and can serve as a representation of something other than itself (DeLoache & Chiong, 2009; Barr et al., 2007; DeLoache & Troseth, 1998; Deocampo & Hudson, 2005). For example, when a child is learning how to read, the child must understand that a letter (i.e., symbol) is a letter on its own but can also convey information about language and sound (i.e., referent) Researchers propose that in order for children to learn from and use symbolic representations, children must understand three important factors about the relationship between a symbol and its referent. The child must (a) recognize that a relationship *exists* between the representation and its referent, (b) understand *how* the representation and referent are related, and (c) understand the *specifics* of the relationship, such as when to use dual representation (DeLoache et al., 1998). These factors serve as the three stages of development to understanding and using symbolic media representations as a source of information (Barr et al., 2007; DeLoache & Chiong, 2009; DeLoache et al., 1998).

During the first stage of development, the dual-representation hypothesis proposes that children from infancy to 15-months do not recognize differences or acknowledge that a relationship exists between a 2-D symbol and its 3-D referent. Therefore, infants treat the symbol as if it were the real 3-D object, or referent (DeLoache et al., 1998; Deocampo & Hudson, 2005). To learn that differences exist between the two, researchers suggest that infants learn through direct, manual exploration of the world (Barr et al., 2007; DeLoache & Chiong, 2009).

In one study, 9- and 19-month-olds were shown video images of real objects to examine their reactions. While viewing the images, every 9-month-old infant attempted to grasp the object. In contrast, the 19-months-old infants pointed to the objects instead of reaching out to touch the images (DeLoache & Chiong, 2009). These results suggest that infants younger than 15-months have not yet developed the understanding that a 2-D representation differs from the 3-D referent. In contrast, the older infants recognized that differences existed between the two by pointing to rather than trying to grasp the images.

As a result, infants up to 15-months may not demonstrate the video deficit effect because children in the first stage treat the 2-D images and 3-D referents as one entity. However, infants older than 15-months are affected when learning from a video because they recognize that differences exist between the 2-D images and 3-D referents (Barr et al., 2007; DeLoache & Chiong, 2009; Deocampo & Hudson, 2005; Strouse & Troseth, 2008).

Barr et al. (2007) showed the differences in development between 12-month and 15-month-old infants, and how the newly acquired information in older infants interferes with children's ability to learn from representational media. In a deferred imitation task in which the infants imitated a 3-step task, the 12-month-old infants displayed no differences in imitation for tasks presented live *or* on a video. In contrast, the older infants' imitation was significantly worse for tasks presented by way of a video demonstration. This finding provides further evidence that around 15-months, children begin to recognize that 2-D images are different from their 3-D referents.

However, 15- to 30-month-old children, who are in the second stage, still have trouble connecting the relationship between the two. In this stage, over time, children become cognizant of how a symbolic media representation relates to its referent and learn that a 2-D image can convey relevant information about their 3-D world (Barr et al., 2007; DeLoache & Chiong, 2009; DeLoache et al., 2008; Deocampo & Hudson, 2005; Strouse & Troseth, 2008). In the beginning of the second stage, children exhibit difficulty learning from symbolic media representations (Barr et al., 2007; Claxton, 2011; DeLoache & Chiong, 2009; Deocampo & Hudson, 2005; Strouse & Troseth, 2008). Researchers suggest that children may recognize that a relationship exists, but do not know how to interpret or use that information (Barr et al., 2007; Claxton, 2011; DeLoache & Chiong, 2009; Deocampo & Hudson, 2005; Strouse & Troseth, 2008).

In this stage, the deficit children experience with symbolic media representations are apparent during video-object retrieval tasks (DeLoache & Chiong, 2009; Deocampo & Hudson, 2005; Lauricella et al., 2010; Troseth & DeLoache, 1998). For example, one study mentioned by DeLoache and Chiong (2009) demonstrated that 2-year-olds were less successful at finding the hidden toy than 2.5-year olds after viewing the experimenter hide the toy through the video monitor. However, 2-year-olds were just as successful as 2.5-year-olds at retrieving the hidden toy after the child viewed the experimenter hide the toy through the window (DeLoache & Chiong, 2009; Deocampo & Hudson, 2005; Troseth & DeLoache, 1998). That is, the 2-year-olds demonstrated the video deficit effect, whereas the 2.5-year-olds did not. The authors suggest that the 2-year-olds in this study seemed to interpret the information presented on the monitor as irrelevant to the retrieval task, and they did not understand that the monitor could provide information needed to successfully retrieve the toy (DeLoache & Chiong, 2009; Troseth & DeLoache, 1998). These results could partly be due to children's inexperience with television in that young children do not typically use TV as a source of information (DeLoache & Chiong, 2009; DeLoache et al., 1998; Deocampo & Hudson, 2005; Hayne et al., 2003; Richert et al., 2011; Strouse & Troseth, 2008; Troseth et al., 2006). However, 2.5-year-old children could successfully find the toy when hidden through the video monitor, indicating that with six additional months of development, children could use the video representation as a source of information.

Around 30-months, children enter the third stage of development in which they begin to understand the specifics of the relationship that can exist between 2-D images and 3-D referents. According to the dual-representation hypothesis, by the time children reach 3.5-years, they can successfully store information about the representation and its referent simultaneously in working memory (Barr et al., 2007; DeLoache & Chiong, 2009; Deocampo & Hudson, 2005; Lauricella et al., 2010). Consequently, children no longer demonstrate the video deficit effect (Barr et al., 2007; DeLoache et al., 1998; Deocampo & Hudson, 2005). As illustrated in the video-object retrieval task, 2.5-year-olds achieved the same success of retrieval of an object independent of whether they watched the toy being hidden through a mirror or by way of a video presentation (DeLoache & Chiong, 2009; Deocampo & Hudson).

In sum, the dual-representation hypothesis proposes that children in the first and third stages can successfully learn from symbolic media representations, although for different reasons. Children in the second stage of development demonstrate deficits in learning from symbolic media representations because of an underdeveloped understanding about the relationship between a 2-D symbol and its 3-D referent. In contrast, the "perceptual impoverishment theory" suggests alternative reasons for children's deficits, as well as a slightly different developmental trajectory throughout the first three years.

Perceptual Impoverishment Theory

The perceptual impoverishment theory proposes a developmental trajectory in which children's understanding of symbolic media representations steadily improves from one year to the next (Hayne, 2004). Authors who support this theory propose that children become increasingly better at learning from and understanding symbolic media representations as children’s memory systems develop throughout the first three years of life (Barr et al., 2007; Bauer et al., 2003; Brito et al., 2007; Hayne, 2004; Hayne et al., 2003; Lauricella et al., 2010; Simcock & DeLoache, 2008; Strouse & Troseth, 2008; Troseth et al., 2006). Hayne (2004) attributed the noticeable developmental differences between infants and toddlers to their ability to encode and retrieve information.

According to the perceptual impoverishment theory, throughout the first three years of life, children’s memory systems begin to develop and become more sophisticated. As children’s memory systems develop, it increases the speed at which children can encode information, allowing children to remember information for longer periods of time, and enabling greater flexibility when retrieving information (Hayne, 2004). During the early stages of development, Hayne suggested that young children’s memories are highly dependent on the availability of matched encoding and retrieval cues. This suggestion is based on the encoding specificity hypothesis, which proposes that memory is more easily recalled when the contextual cues at retrieval match those available during encoding (Tulving, 1983).

In addition to the availability of matched encoding and retrieval cues, Hayne (2004) proposed that the type of cues, enriched or impoverished, can also significantly affect children’s ability to form and recall memories. That is, younger infants and toddlers require rich encoding cues (e.g., colors, shapes, textures, smells) in order to form a strong memory of an object or event, which enables the child to easily retrieve that memory later on. If encoding or retrieval cues are impoverished (e.g., only colors), children may have a more difficult time forming a strong memory, and therefore, later recalling that memory (Bauer et al., 2003; Barr et al., 2007; Brito et al., 2012; Hayne, 2004; Simcock & DeLoache, 2008; Strouse & Troseth, 2008; Troseth et al., 2006). The availability of matched cues, as well as the type of cues available, may explain why children have greater difficulty learning and remembering information from 2-D representations than 3-D representations, and why children gradually become more successful in doing so (Barr et al., 2007; Brito et al., 2007; Carver et al., 2006; Hayne, 2004; Lauricella et al., 2010; Simcock & DeLoache, 2008).

According to the perceptual impoverishment theory, children's difficulty in remembering and applying information from representational media can be attributed to mismatched cues. When children gain information from representational media, children encode 2-D images, which provide the child with impoverished encoding cues (e.g., colors but no texture or dimension). As a result, young children may have more difficulty storing that information into long-term memory and later retrieving it (Barr et al., 2007; Carver, 2006; Hayne, 2004; Zack et al., 2009). Furthermore, applying the 2-D information to the real world creates another obstacle for young children because the 2-D encoding cues do not identically match the 3-D retrieval cues, making it more difficult for the child to recall the memory (Barr et al., 2007; Brito et al., 2012; Hayne, 2004; Zack et al., 2009).

Zack et al. (2009) demonstrated the importance of matched cues during encoding and retrieval on infants' ability to imitate actions viewed on a screen. The researchers included a within-dimensions condition (i.e., 2-D/2-D, 3-D/3-D) in which children viewed the initial demonstration and imitated the actions through the same medium, as well as a between-dimensions condition (i.e., 2-D/3-D, 3-D/2-D) in which children viewed the initial demonstration through a different medium than the imitation test. Zack et al. found that infants performed better when the perceptual encoding cues matched the retrieval cues at the time of test, whereas infants who experienced mismatched encoding and retrieval cues did not perform as well.

In addition to encoding and retrieval cues, the perceptual impoverishment theory also highlights the developmental differences in young children's encoding speed for 2-D images, which can also affect children's memory of 2-D information (Barr et al, 2007; Carver et al., 2006; Hayne, 2004; Strouse & Troseth, 2008). Hayne suggested that children's encoding speed improves as the memory system develops, and that children become increasingly faster at encoding information around the third year of life.

To measure infants' encoding speed, Carver, Meltzoff, and Dawson (2006) examined 18-month-olds event-related potentials (ERP) when viewing familiar and unfamiliar pictures (2-D) and toys (3-D). Infants viewed two 2-D images of toys (one familiar, one unfamiliar), and then two 3-D toys (one familiar, one unfamiliar). The results demonstrated that infants could quickly discriminate between unfamiliar and familiar toys when presented as 3-D objects. However, discrimination rate slowed for both unfamiliar and familiar toys when presented as 2-D images. The results suggest that infants may require more time to adequately encode 2-D information than 3-D information (Barr et al., 2007; Hayne, 2004).

Overall, the perceptual impoverishment theory proposes that children gradually, year by year, become more successful at learning from representational media as their perceptual skills and memory systems develop. As they develop, children learn to encode 2-D information more quickly, adapt to and utilize impoverished cues, and require fewer matched cues to retrieve a memory (Hayne, 2004). As a result, by 36-months, toddlers should be successful at learning from representational media.

Memory for Symbolic Media Representations

The dual-representation hypothesis and the perceptual impoverishment theory help to explain the developmental trajectories of how young children come to use representational media as a source of information. In addition to understanding development, researchers have studied children's retention for symbolic media representations using elicited and deferred imitation tasks, and in doing so, they have identified several factors that can lengthen retention, such as reinstatements (Adler et al., 2000; Hudson & Sheffield, 1998; Sheffield, 2004; Sheffield & Hudson, 2006) or repetitions of actions during the initial demonstration session (Barr et al., 2007; Richert et al., 2011; Simcock & DeLoache, 2008; Strouse & Troseth, 2008; Troseth et al., 2006).

Reinstatements, which serve as a reminder of the events, such as a reenactment of the target actions, have been shown to significantly improve retention of children's memory (Adler et al., 2000; Hudson & Sheffield, 1998; Sheffield, 2004; Sheffield & Hudson, 2006). For example, in Sheffield and Hudson's elicited imitation study, 18-month-old children successfully remembered the target actions from a live demonstration an additional 10 weeks after viewing a video reenactment, which occurred 10 weeks after the initial demonstration session. Furthermore, Sheffield and Hudson showed that 18-month-old children could successfully use a symbolic reminder to remember a 3-D event and successfully transfer information between the two dimensions. Barr et al. (2007) also found that reenactments could improve children's retention of symbolic media representations by demonstrating that performance of 15-month-old children could be improved when given a video reenactment of the initial video demonstration after the initial demonstration and before the testing session. In Barr et al.'s study, children could successfully remember actions from a representational medium using a symbolic reminder. However, in both studies mentioned, children performed better if the initial demonstration was presented live compared to a video.

Repetitions of the desired target actions during the initial demonstration session have also been shown to improve children's memory and performance on deferred imitation tasks (Barr et al., 2007; Crawley et al., 2002; Richert et al., 2011; Simcock & DeLoache, 2008; Strouse & Troseth, 2008; Troseth et al., 2006). Brito et al. (2012) found that showing the video or picture demonstration twice during the initial learning session allowed 18-month-old children to remember events for up to two weeks and 24-month-olds to remember for up to four weeks. Strouse and Troseth (2008) found similar findings in 24-month-olds after a 24-hour delay, but also discovered that only showing the demonstration once impaired performance on the imitation task for children in the video condition, but not for the live condition. These studies convincingly demonstrate that repetitions of a video demonstration can improve memory, but performance still may not equate that of a single or repeated live demonstration.

Additional Factors Influencing Learning

Aside from the factors specifically affecting memory retention, researchers have identified additional factors, such as the type of information being presented (Sheffield, 2004), previous experience (DeLoache et al., 1998; Deocampo & Hudson, 2005; Hayne et al., 2003; Richert et al., 2011; Strouse & Troseth, 2008; Troseth et al., 2006) and the presence of social information (Carver, 2006; Crawley et al., 2002; DeLoache & Chiong, 2009; Lauricella et al., 2012; Richert et al., 2011; Troseth et al., 2006; Zack et al., 2009) on learning from representational media. With regard to the type of information children remember, children have demonstrated a preference for action information over object information. For example, Sheffield (2004) found that 18-month-olds' memory for a past event was facilitated when children were reminded of their original training with the same action on a new object. However, the 18-month-olds were not reminded of their past training when the objects were the same from the original training, but the actions were replaced with new ones. Although Sheffield's study demonstrated children's preferences for action information, there are few studies in the literature that have looked at different types of information children remember more easily, especially when learning from representational media. Researchers suggest, though, that children may be more likely to remember action information because actions are needed to complete goals, and children tend to remember goal-directed behaviors more frequently than nonsense behaviors (Pfeifer & Elsner, 2013). However, more research is needed to determine whether this preference is demonstrated when learning from representational media.

In addition to different types of information affecting what children remember, researchers have also discovered that experience with a symbolic object may negatively affect children's ability to learn from that symbol. For example, DeLoache and Chiong (2009) reported that in a standard object-retrieval task, 3-year-old children could successfully retrieve the hidden toy given the information provided from the scale-model (DeLoache et al., 1998). However, if the 3-year-olds had 5 min beforehand to play with the scale-model, retrieval accuracy declined. This surprising result suggested that experience with the scale-model produced a strong representation of the model as a toy rather than a source of information, and inhibited the child's ability to use it as a symbol.

Furthermore, research has found that the video deficit effect may be a result of children's previous experience and knowledge of TV. That is, children may understand that television characters do not typically convey important information about current situations in the real world, and thus, children do not consider television as a reliable source of information (DeLoache et al., 1998; Deocampo & Hudson, 2005; Hayne et al., 2003; Richert et al., 2011; Strouse & Troseth, 2008; Troseth et al., 2006). In one study, 24-month-olds imitated fewer actions from an in-home video demonstration, which was presented on the home television, than children who viewed the same demonstration in a lab suggesting that children who viewed the tasks on a familiar representational medium (i.e., home television) had more difficulty using the medium as a source of information (Strouse & Troseth, 2008). This study provides evidence that experience with a familiar representational medium may negatively affect children's ability to learn from that medium.

Children's experience with television and video may affect their ability to use them as a valid source of information, but researchers have demonstrated that this effect can be reduced if the TV or video content includes a form of interaction or social information (Carver, 2006; Crawley et al., 2002; DeLoache & Chiong, 2009; Lauricella et al., 2012; Richert et al., 2011; Troseth et al., 2006; Zack et al., 2009). For example, researchers demonstrated that children's learning is boosted from shows such as "Blue's Clues" and "Dora the Explorer" due to the social nature of such shows, which invite children to interact with the characters (Crawly et al., 2006; Troseth et al., 2006).

However, this improvement is dependent on the number of times a child is exposed to these types of shows. That is, the more times a child is exposed to social TV content, for example "Blue's Clues," the more likely the child is to learn from that content (Richert et al., 2011).

Troseth et al. (2006) demonstrated the importance of interactive representational media on learning in 2-year-olds. In a video-object retrieval task, children became familiar with the objects in the hiding room by verbally labeling each possible hiding location (e.g., sofa, chair, table etc.). After becoming familiar with the room, children viewed an interactive or a non-interactive video. The interactive video provided a two-way interaction in which the experimenter called the child by name, made eye contact, smiled, and played games like "Simon Says." The interaction demonstrated to the child that the video could convey relevant information. In the non-interactive video, the child viewed a recorded video of an experimenter from one of the interactive videos. Therefore, the non-interactive video still included some social cues and interaction but included misleading information, as well (e.g., incorrect name). All children then viewed a video of the experimenter asking the child to find a toy in a hidden, labeled location. The researchers found that 2-year-olds in the interactive condition were more likely to find the hidden toy than children in the non-interactive condition, demonstrating that the degree of social interaction and cues can facilitate children's learning from a video.

Lauricella et al. (2010), found consistent results in their study that examined the effects of interaction on 30- and 36-month-old children's performance in a video-object retrieval task. The researchers found that an interactive computer game improved 30- and 36-month olds' performance on the retrieval task more so than a passive video. In the interactive computer game, children received positive feedback for each of their actions, which ultimately improved performance on the task.

In naturalistic settings, young children may receive social feedback (e.g., eye contact, verbal speech) for their actions, which in turn may help them to learn about the environment (DeLoache & Chiong, 2009; Richert et al., 2011; Troseth et al., 2006). Researchers suggest that social cues and social interactions may be an additional and important component to fully understanding how children learn from and remember symbolic media representations (Richert et al., 2011; Troseth et al., 2006). For example, Reysen and Adair (2008) found that, in adults, information presented in a social manner (i.e., information presented by another person) was remembered better than information presented in a non-social manner (i.e., information presented by a computer). If this finding applies to children as well, then interactive representational media, which present information to children in a social manner, should facilitate memory and learning. With the emergence of touch-screen devices, which are increasing in popularity as a learning tool for young children, examining the effects of interaction with these devices on children's memory will add to our understanding of how children use representations to assist recall.

Therefore, this current study determined whether the activity level of a video presentation (i.e., active, passive) could improve children's memory of symbolic media representations to a comparable level of a live demonstration. This current study measured children's ability to imitate activities in the same dimension as the original presentation (e.g., original presentation on tablet, imitation test on tablet), as well as their ability to imitate activities in a different dimension than the original presentation (e.g., original presentation on a tablet, imitation test using toys), in order to determine where the deficit lies. Based on the discussed literature, this study had several hypotheses.

In the present study, children viewed four different stories during a presentation day, viewing one in each different presentation type (i.e., live-active, live-passive, video-active, video-passive). Live and video refer to the dimension of the presentation (i.e., Live: 3-D toys, Video: 2-D, tablet). Active and Passive refer to the activity level during the presentation session (i.e., Active: the child completes the tasks with the experimenter, Passive: the child watches the experimenter complete the task). One week after the presentation day, the same experimenter returned to administer two tests. During each test, the experimenter tested children’s memory for each story by asking children to imitate the targets presented in the stories (e.g., “Do you remember Johnny’s day at the farm? Can you show me what happened at the farm?). During the first test, children were tested on each story within the same dimension as viewed on the presentation day (i.e., Day 1: Story 1, toys, Day 7: Story 1, toys). This is referred to as the memory test. Next, the experimenter tested children’s ability to transfer information between dimensions by asking children to imitate the targets for each story in a different dimension than during the presentation day (e.g., Day 1: Story 1, toys, Day 7: Story 1, video). This is referred to as the transference test. Children’s imitation of the activities when the presentation session and imitation test occurred in the same dimension and in different dimensions was scored to measure children’s memory.

Memory and Transference Hypotheses

Based on the research that suggests that interactive, social media can improve children’s memory by providing feedback to the child and demonstrating that the representational medium can convey relevant information about the real world (Carver, 2006; Crawley et al., 2002; DeLoache & Chiong, 2009; Lauricella et al., 2012; Richert et al., 2011; Troseth et al., 2006; Zack et al., 2009), in addition to the literature that has found that children have greater difficulty learning from a passive video than from an interactive video (Barr et al., 2007; Barr & Wyss, 2008; Brito et al., 2012; Carver, 2006; Crawley et al., 2002; DeLoache & Chiong, 2009; Hayne et al., 2003; Lauricella et al., 2010; Richert et al., 2011; Strouse & Troseth, 2008; Troseth et al., 2006; Zack et al., 2009), it was hypothesized that children would remember more targets (i.e., objects, actions, locations) when presented as an active video than a passive video.

Furthermore, based on the literature supporting the video deficit effect, in which children learn better from live demonstrations than from picture or video demonstrations (Barr, Muentener & Garcia, 2007; Barr & Wyss, 2008; Brito et al., 2012; DeLoache & Chiong, 2009; Hayne et al., 2003; Lauricella et al., 2010; Strouse & Troseth, 2008; Troseth et al., 2006; Zack et al., 2009), it was predicted that children would remember more targets from the live demonstrations (3-D) compared to the video demonstrations (2-D), regardless of whether the presentation sessions and imitation tests occurred in the same or opposite dimensions.

Finally, based on the research suggesting that interactive media can improve children's memory by providing social feedback (Crawley et al., 2002; Lauricella et al., 2012; Richert et al., 2011; Zack et al., 2009), an interaction between dimension and activity level was expected with children remembering more targets in live-active conditions than all other conditions. Additionally, it was hypothesized that children would remember more targets in the 2-D-active conditions than the 2-D-passive conditions.

Based on the perceptual impoverishment theory, which suggests that children's memory is stronger when provided with matched encoding and retrieval cues (Hayne, 2004), as well as Zack et al.'s (2009) study, which found that 15-month-olds had greater difficulty when transferring information between dimensions (2-D to 3-D) than within dimensions (3-D to 3-D) it was hypothesized that children would more easily transfer information during within-dimension tasks (i.e., toys to toys) than between-dimension tasks (i.e., toys to tablet).

Age differences are consistent throughout the literature with older children remembering more information than younger children because older children have developed the cognitive resources needed to learn from and remember symbolic media representations more so than younger children, who are still developing those resources (Barr et al., 2007; Carver, 2006; DeLoache et al., 1998; DeLoache & Chiong, 2009; Deocampo & Hudson, 2005; Hayne, 2004; Troseth et al., 2006). Therefore, an age effect was expected with 36-month-old children remembering more overall target sequences and being able to transfer between dimensions more easily than 30-month-old children.

This study also measured three imitation scores for each child: object, action and location. As previously mentioned, Sheffield (2004) found that 18-month-olds' memory for a past event was facilitated when children were reminded of their original training with the same action on a new object. However, the 18-month-olds were not reminded of their past training when the objects were the same from the original training, but the actions were replaced with new ones. Therefore, this study expected that children would demonstrate a preference for action information over object or location information.

Hypotheses of Individual Differences

The study also examined gender differences, associations with children's daily media exposure, and language development as predictors of performance. Although the literature has failed to document any gender differences on object retrieval or deferred imitation tasks (Barr et al., 2007; Brito et al., 2012; Deocampo & Hudson, 2005; Hudson & Sheffield, 1998; Lauricella et al., 2010; Sheffield & Hudson, 2006; Strouse & Troseth, 2008; Zack et al., 2009), attentional differences are commonly found between boys and girls with girls attending more than boys, which can ultimately affect memory performance during the testing session (Mahone & Schneider, 2012). As a result, gender was used as a variable of performance.

Similarly, the literature has failed to establish a correlation between children's media exposure and performance (Barr & Wyss, 2008; Brito et al., 2012; Lauricella et al., 2010; Strouse & Troseth, 2008). Therefore, no significant associations were expected. However, despite failed findings of a relationship, an association could have risen between children's experience with touch-screen devices and performance due to the increased usage and accessibility of young children with touch-screen devices in more recent years. Children participating in this study were more than likely born into a home where parents have touch-screen devices and, as a result, have additional experience with them compared to children used in previous studies. Consequently, individual differences in experience with and exposure to representational media were still measured as a predictor variable of children's performance.

Finally, individual differences in children's language development were assessed for 30- and 36-month-old children using the MacArthur-Bates Communicative Development Inventories (CDI). This measure was used as a predictor variable of performance on an exploratory basis. The narrations of the story presentations were enriched with labels for each activity in the story. Therefore, children demonstrating superior language development could have performed better than children whose language development may not have been as advanced.

Method

Experimental Design

A mixed-group design was used for this experiment that included five independent variables, two of which were between — Age (30-months, 36-months) and Gender (Girls, Boys) — and three of which were within — Activity Level (Active, Passive), Target (Object, Action, Location), and Presentation Method (3-D objects, 2-D video representations). The dependent variables included production of the target sequences for within-presentation tests (i.e., children were asked to remember the target sequences by producing them using 3-D objects after being trained with those objects, or asked to remember the target sequences by producing them using a computer tablet after being trained on the computer tablet) as well as production of target sequences for between-presentation tests (i.e., children were asked to remember the target sequences by producing them using 3-D objects after being trained on a 2-D computer tablet, or children were asked to remember the target sequences by producing them using the 2-D tablet after being trained with the 3-D objects). Each target sequence included an object, an action, and a location or destination (see Table 1 for all target sequences). For example, in the Farm Story, Johnny must choose the red car (object), put Johnny on the car (action), and put Johnny in the correct location on the car.

{Insert Table 1 here}

Participants

Participants consisted of 59 children (21 girls and 24 boys). Seven 30-month-olds and five 36-month-olds completed the presentation session but were unable to complete the testing session due to inclement weather, illness, or other events. Two children were eliminated from the data because they refused to participate during the testing session. Resulting participants consisted of 45 preschool children. Sixteen children were 30-month-olds (± 2 months; M_{age} = 30 months) and 29 were 36-month-olds (± 2 months; M_{age} = 37 months). Of the 30-month-olds, there were 7 girls and 9 boys. Of the 36-month-olds, there were 14 girls and 15 boys.

Children were recruited through local preschools in Baltimore County. Directors of the participating preschools completed a director consent form before parental consent forms were distributed. Only children whose parents completed the parental consent forms participated in the study. In addition, each child gave their assent before beginning the tasks to ensure that they wanted to participate (i.e., coloring in a smiley face to participate). The preschools received $10.00 for each child that completed the study.

Materials and Apparatus

Technology. Video presentations were displayed on a Samsung Galaxy tablet (10.1 inches diagonally). Children viewed one video and interacted with another video on the tablet while the experimenter held the tablet. During the passive presentations, the experimenter asked the children to listen carefully and instructed children to fold their hands nicely if there were attempts to reach or touch the screen.

A video camera (JVC HDD) was used to record during the sessions. During the first session, an experimenter recorded baseline activity for each story, and during the second session, the experimenter recorded children's production during memory and transference tests. Video recordings were used to code the baseline and test sessions.

Three-dimensional stimuli. Each story had a set of toys with which children interacted. The toys were used to measure baseline activity in all four stories and were used to demonstrate two of the stories during the first session. During the second session, the toys were used to measure children's memory of those toys and to measure transfer of learning (i.e., children who were presented with a story on tablet were tested with the toys; see Table 2 for details).

{Insert Table 2 here}

The toys and narratives were carefully chosen to be unfamiliar to children to minimize the chance that familiarity would become a confounding variable (Hudson & Nelson, 1983). If children were familiar with the objects or stories, they may too easily understand affordances instead of having to learn a new set of tasks and demonstrate memory for those specific tasks. In addition, if children were to have seen these objects often in their daily activities, inadvertent reinstatements could occur between presentation and testing sessions (Hudson & Sheffield, 1998; Sheffield & Hudson, 2006; Sheffield, 2004; Bauer et al., 2003; Adler et al., 2000; Wenner & Bauer, 1999).

Video presentations. A professional Flash programmer created the videos for each story, which were created using photographs of the 3-D toys used during for the live conditions. The videos were in color and lasted approximately 90 to 120 s. The time of each video was dependent on whether the child actively participated or listened and whether any glitches occurred during the presentations. The videos did not include audio. Instead, the experimenter narrated the stories using a script to maintain consistency throughout all presentations (see Appendices A - D for story scripts).

For each tablet story, the first screen presented pictures of all of the objects that were included in the story to mimic the setup and presentations during the live conditions. However, there were no interactive capabilities during the first screen of any story. The experimenter then hit a hidden "next" button that would present a new screen. Each proceeding screen isolated the desired objects and allowed the desired actions to be completed. When objects were selected, a halo of color was presented around the object to show that the object had been selected (see Appendix E).

The videos were used to present two of the stories during the first visit and to test children's memory (i.e., presented the story on the tablet, tested on the tablet) and transfer of learning (i.e., presented the story with the toys, tested on the tablet) during the second visit. Memory and transfer of learning for video conditions were measured by children's ability to imitate the four targets that occurred in each of the four stories using the interactive video associated with the story.

A short practice video was also created to ensure that children could use the tablet and would be able to complete the tasks during the presentation and testing sessions. The practice video had a picture of a bus, a bear, and a monkey. The children could navigate the bear and the monkey around the screen. The experimenter showed the children how to click on the objects and drag them each to the school bus. The experimenter then put the objects back in their original locations and asked the child to produce the same actions. The practice video lasted approximately 45 s. If a child could not complete the desired actions after three consecutive tries, the child did not continue on to the presentation session and the child was brought back to class.

Measures of Individual Differences

MacArthur-Bates communicative development inventory (CDI-III). The Communicative Development Inventory III (CDI-III) measures expressive vocabulary and grammar for children between the ages of 30- to 37-months. The CDI-III is a parent survey that consists of three subsections. In Section 1, measuring expressive vocabulary, parents check off words that their child can successfully produce from a list of 100 vocabulary words. Sections 2 and 3 measure children's grammar skills by asking parents 13 questions about their child's word combinations and sentence pairs, as well as 12 "Yes" or "No" questions concerning comprehension, semantics, and syntax. The CDI-III has an internal reliability correlation of .86 and a test-retest reliability of .95. The CDI-II has been validated with other measures such the Preschool Language Scale-3 (r = .63) and Picture Vocabulary Test-Revised (r = .63). The CDI-III was completed for both 30- and 36-month-old children in the study. Parents for children who completed both the presentation and testing session completed the survey via e-mail or phone (see Appendix F).

Parent media survey. Parents of children who completed both the presentation and testing session completed the Parent Media Survey. The survey consisted of 15 questions that measured children's time spent exposed to media, identified exposure and experience with representational media (e.g., computers, tablet computers, etc.) and media content, and identified parent perceptions on the importance of media content and other activities (e.g., reading, playing with toys, etc.). The survey was completed via e-mail or over the phone (see Appendix G).

Procedure

Presentation session. Children were escorted by the experimenter into a quiet room within the preschool and seated on the floor. Before beginning, the children were presented with the assent form (i.e., smiley face, frown face) and were asked, "Do you want to hear some stories today? If you do want to hear the stories, you can draw on the smiley face. If you do not want to hear the stories, you can draw on the frown face." If the child colored the smiley face, the presentation session began. If the child circled the frown face, the child was brought back to their classroom.

After completing the assent form, each child was shown a practice video on the tablet. When beginning the practice video, the experimenter asked the child if they had ever seen or used a tablet before. Then, the experimenter demonstrated to the child how to tap on objects and drag those objects to a desired location (e.g., tap on the monkey and drag the monkey to the school bus). Then the experimenter replaced the objects to their original locations and asked the child to imitate the same actions. The experimenter allowed the child to complete up to three practice trials before deciding if the child could successfully use the tablet and understand the task. If the child successfully completed the practice video, the presentation session began. If the child could not successfully complete the practice video after three tries, the child was escorted back to class.

Before the beginning of each story, the toys associated with that story were presented to the child and the experimenter asked the child to use their hands to show what they could do with the toys. This served as the baseline measure to determine which objects, actions, or locations could be naturally produced before introducing the story. Children were allotted approximately 60 s to produce any baseline targets. After each baseline, the experimenter presented the story.

Children viewed a story in each of the four presentation types (i.e., Live-Active, Live-Passive, Video-Active, Video-Passive). During the active presentations, the children actively participated in completing the targets throughout the story. In order to ensure that children completed the correct targets during the active presentations, the experimenter directed the child's attention to the correct object by pointing to it and then verbally asked the child to complete the correct action using the correct object and placing it in the correct location (e.g., "Can you put Johnny on the red car?"). During the passive presentations, children simply watched the experimenter complete the targets throughout the story. If a child attempted to participate, the experimenter would remind the child that it was their turn to tell the story and asked them to keep their hands folded nicely.

After the first two story presentations, the child had a 2 min break in which they colored in a picture with crayons with the second experimenter. The break helped the children sustain attention needed to complete all four stories. After the break, children completed the remaining two stories.

After the presentation of all four stories, children received stickers and were escorted back to their classroom by a teacher or the second experimenter. The presentation session lasted approximately 12-15 min.

Testing session. One week after the presentation session, children were brought back into the same room as the presentation day for testing. The same experimenter attended both sessions in order to maximize the number of matched encoding and retrieval cues, which have been shown to improve memory recall (Hayne, 2004; Hayne et al., 2003; Troseth et al., 2006). Once the child was seated, the experimenter began the testing session. The stories were tested in the same order in which the child viewed the stories during the presentation session. The experimenter first tested children's memory (e.g., If presented with during the presentation session, imitated targets using the toys on the testing session) followed immediately after with the transference test (e.g., If presented with toys during the presentation session, imitated targets using the tablet on testing session).

For the memory test, the experimenter presented the child with either the toys or the interactive video associated with the first story. For example, if a child viewed Story 1 as a passive or interactive video during the presentation session, the child imitated the targets using the interactive video of Story 1 during the testing session. After completing the memory test, children completed the transference test in which they were tested in the opposite dimension from the presentation session using the toys or the interactive video. Both the memory and the transference tests were completed for the first story before moving to the next.

For both memory and transference, children were asked to produce the targets associated with each story. During the tests, the experimenter prompted the child by asking them what they remembered from the story (e.g., "Do you remember Johnny's day at the farm?") and then asked the child to demonstrate what happened in each story using the toys or the interactive video (e.g., "Can you show me what Johnny did at the farm? I forget."). As during the presentation session, children received a 2 min break to color in a picture after completing the memory and transference tests for the first two stories. The testing session lasted approximately 12 – 15 min.

Assessments of individual differences. Parent calling and e-mails occurred after children completed both presentation and testing sessions. The experimenter first e-mailed parents the McArthur–Bates Communicative Developmental Inventory (CDI-III) and the Parent Media Survey with instructions. If the parents did not respond after five days, the parents received a follow-up e-mail to remind them of the surveys. After a week from which the original e-mail was sent, if there was still no response, the experimenter called the parents and either left a message or asked them to complete the surveys on the computer. The CDI-III and the Parent Media Survey were completed for both 30- and 36-month-old children. However, six of the 45 parents did not complete the Parent Media Survey and eight of the 45 parents did not complete the CDI-III.

Scoring

Coding.

Two different experimenters coded each child’s performance. Inter-rater reliability was highly correlated, $r = .98$, indicating that experimenters were consistently and accurately coding performance.

Each story the child completed contained four target sequences with each sequence including an object, an action, and a location or destination. Each target (i.e., object, action, location) was coded with either a “1” or a “0” (1 = completed, 0 = incomplete). For example, in the Farm Story, if the child put Johnny on the red car during one of the imitation tests, the child would receive a “1” for the child choosing the *red car* (object), a “1” for putting Johnny on the car (action) and a “1” for putting Johnny in the front of the car (location). Therefore, children could receive a total score of “4” for each type of target information within one story.

Only the first activity produced by the child was coded. However, if the child chose one object and completed an action, but then immediately chose the other object and completed the same action, the child received a “0” for object but a “1” for action. For example, in the Cake Story, if the child first put the crown on the cake and then immediately after put the cupcake on the cake, the child only received credit for completing the correct action and location. We chose to code this way because the child, in that example, may not have been demonstrating a strong memory of one object or the other, but more likely was demonstrating a strong memory for the action and location.

Calculating scores.

We calculated individual *object, action, and location scores* for each story. That is, we added up the points for correctly completed objects, correctly completed actions, and correctly completed locations for each story. Within each story there were four difference objects, four different actions, and four different locations to remember. Therefore, children could receive a total score of "4" for each type of information – object, action, location – for each story.

In order to account for baseline production, scores were calculated by subtracting the activities produced during baseline from the activities produced during testing. For example, if the child put Johnny on the blue car during baseline, the child would receive a "0" for object, a "1" for activity, and "1" for location. If during the testing session the child puts Johnny on the red car, the child would receive a "1" for all three - object, action and location. However, because the child naturally produced the action and location activities during baseline, the baseline scores were subtracted from the activity scores (e.g., Baseline Action – Memory Action).

Results

Preliminary Analyses

A 4 (Story Order: Story 1, Story 2, Story 3, Story 4) x 4 (Presentation Order: 2-D passive, 2-D active, 3-D passive, 3-D active) x 16 (Activity) between groups analysis of variance (ANOVA) was conducted to determine if the counterbalanced story orders, presentation orders or activities affected children's overall scores. The analysis revealed a significant main effect of Activity, $F(15, 720) = 1.78$, $p = .03$, power = .93.A Tukey-Kramer Multiple Comparison Test showed that children remembered the elephant activity ($M = 0.52$) more frequently than all other activities and remembered the decorations activity ($M = 0.13$) less frequently than all other activities. The ANOVA also revealed a significant Story Order x Presentation Order interaction effect, $F(9, 720) = 2.93$, $p < .01$, power = 0.97. However, the last group order contained one participant, whereas the others contained four participants. Both Story Order and Presentation Order were rejected in a Shapiro-Wilk W Test of Normality due to unequal numbers of participants per condition, $p > .05$. Additionally, story orders and presentation orders were counterbalanced among participants such that a quarter received Story Order A, a quarter received Story Order B, etc. and therefore, we believe those factors were controlled for in the experimental design.

A one-way repeated measures ANOVA was conducted to determine if children's activity scores improved or declined over the course of the four stories. The analysis failed to reach significance, $p > .05$, indicating that children did not demonstrate any recency or primacy effects or fatigue over the four stories.

Total Scores

Recall that one of our leading hypotheses was that children would recall more information when the presentation session and imitation test occurred in the same dimension (i.e., toys to toys, tablet to tablet) rather than in different dimensions (i.e., toys to tablet, tablet to toys). In addition, we wanted to learn whether certain information (i.e., object, action, or location information) would be remembered more when the presentation session and imitation test occurred in the same or different dimensions. Therefore, a 2 (Age: 36-months, 30-months) x 2 (Gender: Boy, Girl) x 3 (Target: Object, Action, Location) x 2 (Test: Memory, Transference) mixed groups ANOVA was analyzed on children's total scores.

The analysis revealed a significant main effect of age, $F(1, 270) = 64.26$, $p < .01$, power = 1.00, with 36-month-olds ($M = 8.33$) recalling more information than 30-month-olds ($M = 5.54$). The analysis also revealed a significant effect of gender, $F(1, 270) = 29.07$, $p < .01$, power = 1.00, with girls ($M = 7.86$) recalling more information than boys ($M = 6$). Furthermore, the analysis revealed a significant effect of target, $F(2, 270) = 9.52$, $p < .01$, power = .98, with children remembering more action information ($M = 8$) more than object ($M = 6.5$) and location ($M = 6.34$) information. A Tukey-Kramer Multiple-Comparison Test indicated that actions were significantly different from objects and locations, $p < .05$. Additionally, the ANOVA indicated a significant main effect of test, $F(1, 270) = 5.75$, $p = .02$, power = .67, with children remembering significantly more information when the presentation sessions and imitation tests occurred in the same dimension ($M = 7.35$) rather than occurring in opposite dimensions ($M = 6.52$). Finally, the analysis revealed a significant Age x Target interaction effect, $F(2, 270) = 3.06$, $p = .05$, power = .59, with 30-month-old children recalling more object information ($M = 5.68$) than location information ($M = 4.6$) and 36-month-old children recalling more location information ($M = 8.06$) than object information ($M = 7.26$). Children of both ages recalled more action information than object or location information (see Figure 1).

{Insert Figure 1 here}

Memory (Within-Dimension) Analyses

Recall that for each target an object, action, and location was coded. Therefore, a 2 (Age: 36-months, 30-months) x 2 (Gender: Boy, Girl) x 2 (Action: Active, Passive) x 2 (Dimension: Training on tablet in 2-D, training on real-world 3-D toys) x 3 (Target: Object, Action, Location) mixed groups ANOVA was conducted on children's memory scores. The analysis revealed a significant main effect of age, $F(1, 540) = 45.56$, $p < .01$, power = 1.00, with 36-month-old children ($M = 2.18$) remembering significantly more than 30-month-old children ($M = 1.50$). The analysis also revealed a significant main effect of gender, $F(1, 540) = 9.03$, $p < .01$, power = 0.85, with girls ($M = 1.99$) remembering significantly more than boys ($M = 1.67$). Finally, the analysis revealed a significant main effect of target, $F(2, 540) = 8.01$, $p < .01$, power = 0.96, with children remembering more actions ($M = 2.13$) than locations ($M = 1.70$) and objects ($M = 1.69$). A Tukey-Kramer Multiple-Comparison Test indicated that actions were significantly different from objects and locations, $p < .05$. Furthermore, the analysis revealed a significant Age x Gender x Dimension interaction, $F(1, 540) = 5.43$, $p = .021$, power = 0.64, with 30-month-old boys ($M = 1.35$) remembering fewer targets when they were trained on the tablet than 30-month-old girls ($M = 1.88$), 36-month-old boys

(*M* = 2.15) and 36-month-old girls (*M* = 2.28). Additionally, 36-month-old girls (*M* = 2.42) remembered more targets when they were trained on real-world objects than 36-month-old boys (*M* = 1.87), 30 month-old girls (1.38) and 30-month-old boys (*M* = 1.37; see Table 3).

{Insert Table 3 here}

Transference (Between-Dimension) Analyses

A 2 (Age: 30-months, 36-months) x 2 (Gender: Boy, Girl) x 2 (Action: Active, Passive) x 2 (Dimension: 2-D, 3-D) x 3 (Target: Object, Action, Location) mixed groups ANOVA was conducted on children's memory on the between-dimensions test. The analysis revealed a significant main effect of age, $F(1, 540) = 44.26$, $p < .01$, power = 1.00, with 36-month-olds (*M* = 1.98) producing significantly more responses per target than 30-month-olds (*M* =1.28). The analysis also revealed a significant main effect of gender, $F(1, 540) = 32.25$, $p < .01$, power = 1.00, with girls (*M* = 1.95) producing significantly more responses than boys (*M* = 1.31). In addition, the analysis revealed a significant main effect of dimension, $F(1, 540) = 36.61$, $p < .01$, power = 1.00, with children producing significantly more responses per target when transferring from 3-D to 2-D (*M* = 1.95) than 2D to 3D (*M* = 1.31). The same ANOVA indicated a significant main effect of target, $F(2, 540) = 5.61$, $p < .01$, power = 0.86, with children producing more actions (*M* = 1.88) than locations (*M* = 1.47) and more locations than objects (*M* = 1.55). The ANOVA revealed a significant Activity Level x Target interaction effect, $F(2, 540) = 3.52$, $p = .03$, power = 0.66, with children producing more objects when children actively participated in the story (*M* = 1.67) than when they passively listened and watched (*M* = 1.43). Additionally, this analysis reveals that children produced more actions (*M* = 1.98) and locations (*M* = 1.7) when they passively listened and watched (*M* = 1.78) than when they actively participated (*M* = 1.2) respectively (see Figure 2).

{Insert Figure 2 here}

Parent Media Survey and CDI-III

The Parent Media Survey and CDI-III were administered to all parents whose children completed both sessions in order to determine if exposure and experience with media and language development could predict children's recall for the events. Before running any analyses, the Parent Media Survey was divided into five subcategories: Parental Perceptions, Media Exposure, Parental Participation, Parental Monitoring, and Language Development (see Appendix H). Question 5 was eliminated from all analyses because it did not fit into one of the four categories. The subcategory Language Development included measures from the CDI-III as well as three questions from the Parent Media Survey.

Pearson correlations were used to determine whether the five subcategories were related to children's total recall scores for when the presentation session and imitation test occurred in the same or different dimensions. Components of the Language Development subcategory were the only ones related to children's recall for both when the presentation session and imitation test occurred in the same of different dimensions.

When the presentation session and imitation test occurred in the same dimensions, sentence usage, $r = .640$, language understanding, $r = .560$, vocabulary, $r = .445$, and sentence production, $r = .437$, $p < .01$, were significantly correlated to children's recall with more developed language skills being related to higher recall. When the presentation session and imitation test occurred in different dimensions, sentence usage, $r = .613$, language understanding, $r = .562$, and sentence production, $r = .522$, $p < .01$, were significantly correlated to children's recall with more developed language skills being related to higher recall.

Due to the fact that language development was the only category to be significantly related to children's performance, we wanted to determine whether language development was related to children's recall for the different types of information (i.e., object, action, location) when the presentation session and imitation test occurred in the same or different dimension.

Correlations were first run on children's recall for object information. The analyses revealed that sentence understanding was significantly and positively correlated with children's recall when the presentation session and imitation test occurred in the same, $r = .383$, or different dimensions, $r = .403$, $p < .01$. That is, a higher understanding of sentence structure was significantly related to higher recall of object information in children.

Correlations were also run on children's recall of action information. The analyses revealed that sentence understanding, language usage, sentence production and vocabulary were significantly and positively correlated with children's recall when the presentation session and imitation test occurred in the same or different dimension, $p < .01$ (see Table 4). That is, a higher score in each of these areas of language development was significantly related to higher recall of action information in children.

Finally, correlations were also run on children's recall of location information. The analyses revealed that sentence understanding, language usage, and vocabulary were significantly and positively correlated with children's recall of location information when the presentation session and imitation test occurred in the same or different dimensions, $p < .01$ (see Table 5). That is, a higher score in each of these areas of language development was significantly related to higher recall of location information in children.

Discussion

The goal of the current study was to identify factors that can influence young children's ability to remember information learned on representational media (e.g., TVs, computer tablets) such as active participation compared to passive participation (i.e., watching and listening) during the learning process, in addition to discovering whether children remembered certain types of information better than others when learning from representational media. Finally, the current study measured whether children's deficits in learning from representational media occurred when their memory was tested on representational media or when children had to transfer information from representational media to the real world.

The results from this study support findings from previous research regarding developmental differences in children's learning from representational media and provide further evidence that very young children perform memory tasks less accurately when using representational media as a source of information. Surprisingly, we did not find active participation during the learning process to be advantageous over passive participation as we expected. However, we did find that the type of information being presented and the type of transfer (i.e., whether the child is asked to transfer information from a representational device to the real world or visa verse) affects young children's memory.

Not surprisingly, we found that older children remembered more information than younger children when asked to imitate activities regardless of whether they were presented and tested with information on a tablet or with real-world objects. Further, older children were better at transferring information they learned from the tablet to real world objects, and visa verse. This finding is not only consistent with the memory literature suggesting that maturing strengthens memory in general (Carver, Bauer, & Nelson, 2000; DeLoache & Chiong, 2009; Hayne, 2004), but is also consistent with the literature suggesting that older children learn from representational media more easily than younger children (DeLoache & Chiong, 2009).

With regard to transferring between 2-D representations and the real world, according to the dual-representational hypothesis, children in the third stage of development (i.e., 30-months to 36-months) are beginning to understand the specifics of the relationship between the symbolic media representation and its 3-D referent. Understanding the specifics of the relationship allow children to successfully learn from and remember symbolic media representations (DeLoache & Chiong, 2009; DeLoache, Uttal, & Pierroutsakos, 1998). This theory was supported with results from the current study, which demonstrated that 36-month-old children transferred more information than 30-month-old children. This suggests that 36-month-old children were better able to hold information about the symbolic media representation and its referent simultaneously than were 30-month-old children who were just entering the third stage.

Findings are also consistent with the perceptual impoverishment theory, which suggests that older children should perform better than younger children because their memory systems are more developed. According to the perceptual impoverishment theory, children become progressively more successful at learning from representational media throughout the first three years of life because children become better at using encoding and retrieval cues and can process information more quickly (Carver, Meltzoff, & Dawson, 2006; Hayne, 2004). These skills facilitate children's ability to learn from representational media and can explain the age differences found in this current study with older children remembering more information than younger children.

In addition to age-related differences, the current study found strong gender differences, which have not been commonly found. Girls remembered more information than boys when asked to recall the targets in the same dimension in which the stories were originally presented (i.e., toys to toys, tablet to tablet). Girls also produced more targets than boys when asked to recall the targets in a different dimension in which the stories were originally presented (i.e., toys to tablet, tablet to toys). We believe that this finding may be explained by differences in attention between boys and girls. Research suggests that girls may develop attention skills before boys (Mahone & Schneider, 2012). The tasks in the current study required children to attend to various types of information such as the object, action, and location information for each target that occurred in the stories, and it was observed that girls tended to pay better attention throughout the stories than did boys. If girls were attending more than boys to the targets throughout each of the demonstrations, this would explain why girls remembered and transferred information better than boys.

The tasks we used also contained narratives for each of the stories. It has been demonstrated that girls perform better on verbal tasks than boys throughout the lifespan (Herlitz, Nilsson, & Backman, 1997; Lowe, Mayfield, & Reynolds, 2003). It is possible that girls were better able to use the verbal information provided by the experimenter to encode the information and, as a result, remember more from each story.

Additionally, we found that children's language development was related to children's recall. High scores in sentence production, language understanding, sentence usage and expansive vocabularies were related to higher recall of target information suggesting that sophisticated language development in children is advantageous for young children when learning from representational media. Of course, it may be argued that sophisticated language at an early age is correlated with other mental abilities, so this correlation may be indicating a larger issue as well.

As previously mentioned, girls produced more targets than boys. However, the current study also found that when the original demonstration and imitation of the story targets occurred in the same dimension (i.e., tablet to tablet, toys to toys), 30-month-old girls and 36-six-month old boys remembered more when the original demonstration was presented on the tablet than with the toys. Conversely, 36-month-old girls demonstrated the opposite effect, performing better when the original presentation was presented with toys than on the tablet. Thirty-month-old boys remembered the least of all groups, but recalled equal amounts of information when learning from the tablet or the toys.

The finding that 36-month-old boys and 30-month-old girls remembered more information when the original demonstration was presented on the tablet rather than the toys is inconsistent with findings found throughout the literature, which suggest that all young children should remember more information when the information is presented live than when presented on a representational medium. (Barr et al., 2007; Hayne et al., 2003; Lauricella et al., 2010; Strouse & Troseth, 2008; Troseth & DeLoache, 1998; Zack et al., 2009). These findings may be a result of the differences in the temporal ordering of the tasks between the video and toy demonstrations and imitation tests. In the current experiment, during the toy demonstrations and imitation tests, all of the objects in the stories were visible and accessible to the child at all times during the story. As a result, the stories became arbitrarily ordered in that any action could occur during any point in the story. During the video demonstration and imitation tests, all of the objects in the story were only visible during the first screen shot but could not be manipulated. Each following screen shot only showed the objects involved in the target and only the target actions could be completed before moving on to the next target. Thus, the structure of the task may have encouraged children to perform the desired targets more so than in the live presentations or imitation tests, which provided less temporal information about the order of events.

Research has demonstrated that the temporal order of the story (i.e., arbitrary or enabling) can affect children's memory for events, and that enabling tasks facilitate children memories for events (Bauer, 1992; Bauer & Mandler, 1992; Fivush, Kuebli, & Clubb, 1992). For example, Bauer (1992) found in an immediate imitation task that 20- and 25-month-old children performed better on 3-step tasks when the actions were enabling compared to arbitrary. Bauer suggested that enabling tasks allow children to chunk the information together, which in turn reduced their cognitive load. This could explain why 30-month-old girls and 36-month-old boys recalled more information when the original presentation was demonstrated on the tablet rather than with the toys, in that the enabling tasks in the video demonstrations facilitated children's memory for the tasks, whereas the arbitrarily ordered tasks permitted in the live demonstrations hindered children's memory for the tasks. However, more research is needed to confirm this finding.

Our results with 36-month-old girls can be supported by the video deficit effect in which children learn better from a live demonstration than a video demonstration (Barr et al., 2007; Hayne et al., 2003; Lauricella et al., 2010; Strouse & Troseth, 2008; Troseth & DeLoache, 1998; Zack et al., 2009). Although the two theories both suggest that children around 36-months should be able to successfully learn from representational media, we found that children still had an advantage to learning from a live demonstration than from a video demonstration. The nature of the tasks used may have reduced older children's ability to successfully recall information presented on representational media. The tasks presented to the children were narrated and presented as stories, which may have affected children's ability to remember the tasks. Research suggests that children develop story comprehension between 3 and 5 years (Skarakis-Doyle & Dempsey, 2008). Therefore, it may be that older children had difficulty comprehending the story, which interfered with their memory of the tasks. Future research should assess young children's memory for e-books to determine if development of story comprehension affects children's ability to learn from representational media.

Another important finding from this study was that both boys and girls performed better when transferring information from the toys to the tablet than when transferring information from the tablet to the toys. Although this effect was found for all children, it was stronger for girls than it was for boys. That is, girls were better at transferring information from toys to the tablet compared to the boys.

This effect is supported throughout the literature and provides more evidence for the video deficit effect. Several studies have found that children learn better from live demonstrations than for video demonstrations (Lauricella et al., 2010; Strouse & Troseth, 2008; Troseth & DeLoache, 1998; Zack et al., 2009; Barr et al., 2007; Hayne et al., 2003). However, the results from the current study help to differentiate where the actual deficit lies. It is not that children always learn better from live demonstrations than from video demonstrations. Instead, it appears that children learn better from a live demonstration than from a video demonstration when they have to transfer information between the two dimensions. This effect was not found when the original demonstrations and imitation tests were presented in the same dimension. That is, children performed equally well regardless of whether the demonstration was presented on the tablet or with the toys. Similar results were found in Zack et al.'s (2009) study with 15-month-old children. In Zack et al.'s study, children imitated more actions when the demonstration medium and imitation medium were matched (i.e., within dimensions) than when the demonstration medium and imitation medium were different (i.e., between dimensions).

The results of the current study as well as Zack et al.'s (2009) study can be explained by the perceptual impoverishment theory and its emphasis on the importance of matched encoding and retrieval cues. The matched 2-D cues between the demonstration and the imitation test allow children to successfully learn from representational media (Hayne, 2004). These results demonstrate that young children do indeed have the ability to learn from representational media. However, their memory is dependent on how their memory is tested: within dimensions or between dimensions.

When assessing children's memory for symbolic media representations, it is also important look at the type of information children are remembering – whether it is object, action, or location information. Most studies only assess children's memory for action information in imitation paradigms using multi-step tasks, such as assembling a rattle, which require children to only remember the actions needed to assemble the rattle (Barr et al., 2007; Brito et al., 2012; Strouse & Troseth, 2008). In the current study, we examined children's memory for object, action, and location information.

We found that in all cases, children remembered *action* information more than object and location information. This finding was expected based on Sheffield's (2004) study, which found that children could be reminded of an event if the objects changed but the actions remained the same from the original demonstration. These findings suggest that, for at least the tasks in this study, there was a preference for action information over other information. This may be because actions are critical to goal-directed behaviors (Pfeifer & Elsner, 2013). As a result, the goal is most important and any information that helps get to the goal state is more memorable than other information, such as the end result (i.e., location) of the action.

Although children always remembered more actions than objects or locations, we found that if children participated in completing the targets during the original presentations, it changed the type of secondary information they remembered. However, this only occurred when children were transferring information (i.e., toys to tablet, tablet to toys). We found that children remembered object information more than location information when they actively participated during the demonstration of the stories compared to when they passively watched and listened. Interestingly, when children passively watched and listened during the demonstrations, they remembered more information about the locations than the objects.

Children may have remembered more information about the objects involved in the targets when they actively participated during the story demonstrations because they were able to interact with the objects making a more salient memory at the cost of encoding location information. Contrarily, when children passively watched during the demonstrations, they may have been attending more to the end state of the action – the location. The attention given to the location information may have hindered children's ability to encode information about the object.

Differences in children's attention may also explain why 36-month-old children recalled different information than 30-month-old children. Although children of both ages remembered more action information, 36-month-old children recalled more location than object information, whereas 30-month-old children demonstrated the opposite. This may be due to older children attending more to the end-state of the action, the location, and younger children attending more to the means of completing the action, the object. However, this is the first study to assess children's memory for different types of information in an imitation paradigm. As a result, more research is needed to determine whether these findings hold true in similar paradigms and determine what other factors influence the type of information children remember.

Although we found many results that are consistent with the literature, there were several limitations to the study that deserve consideration. One of the biggest limitations was the difference in temporal ordering of the tasks between the video and live demonstrations and imitation tests. As previously mentioned, the videos provided more enabling tasks in that children had to complete one target (i.e., object, action, location sequence) before moving on to the next one. In contrast, the live conditions provided a freer environment in that children could complete any target in any temporal order. Again, the literature suggests that children of all ages remember enabling tasks better than arbitrary tasks. As we did not control for this in the current study, it may have improved children's memory for stories presented on the tablet.

Another limitation to the study was the Flash videos created for the tablet. Many times during the demonstrations or during the imitation tests, the videos would glitch making the objects disappear from the screen or making the objects impossible to drag to complete the correct actions. Although this was easily corrected by going back to the previous screen, this allowed children to see or complete a specific target more than one time. Previous research has shown that repetition can improve children's memory for events viewed on a video (Barr et al., 2007; Richert et al., 2011; Simcock & DeLoache, 2008; Strouse & Troseth, 2008; Troseth et al., 2006). As a result, this may have also improved children's memory for targets that were repeated that were viewed or completed on the tablet.

Finally, based on the low scores from children of both ages, particularly the 36-month-old children, the tasks used in the current study may have been a bit too difficult for children. As previously mentioned, most studies throughout the literature tend to use one 3-step task. In the current study, we used four 4-step tasks and each task consisted of four targets (i.e., object, action, location sequences). It is possible that the tasks were too cognitively demanding for children of this age. However, Bauer (1992) found in an immediate imitation task that 20-month-old children could successfully remember four 4-step tasks so the idea that the tasks were too cognitively demanding may not fully explain why children did not perform well.

Conclusions

The findings from this study add to the body of literature regarding children's ability to learn from representational media. The results suggest that children can remember events from representation media if their memory is also tested on a representational medium. The deficit in young children's memory seems only to occur when they must transfer the information they learned on a representational medium to the real world or vice versa. It would be interesting to determine whether children can generalize the information learned on one representational medium to another. For example, if a child learns a series of events on a computer tablet, can they transfer the information to a TV or computer? That has not yet been explored in the literature but would speak to whether transference in general is the issue or transference between dimensions is the issue.

The current study also suggests that children attend more to action information than object or location information. However, the amount of object and location information remembered is dependent on whether children are able to actively participate or passively watch during the learning process. Although active participation does not seem to affect what children remember from representational media on its own, it does have implications when remembering object and location information. Nonetheless, this is the first study to find this effect and more research is needed to support this finding.

Overall, it is important to know that young children can learn from representational media if given the right circumstances to demonstrate their knowledge. With this research we have begun to explore how children may learn from technology. The future of learning is through technology, and it is happening now. Therefore, it is essential to continue to understand how children learn from representational media to improve the future education of children in today’s society

Table 1.

Target Objects, Actions, and Locations for Each Story

	Targets		
Story	Object	Action	Location
Story 1	Red Car	Put Johnny on Car	Front of car
	Sand	Place Johnny on sand	On top of sand
		Feed zebra corn	In pen
	Corn	Put next to zebra	Next to zebra
	Elephant	Place next to zebra	Next to zebra
Story 2	Red Icing	Place icing on top of cake	On top of cake
	White cotton balls	Place on top of cake	On sides of cake
	Crown	Place on top of cake	In center of cake
	Beads	Place around cake	Around cake
Story 3	Rectangle stamp	Place on envelope	Corner of envelope
	Monkey sticker	Place on envelope	Center of envelope
	Red mailbox	Place envelope in mailbox	In mailbox
	Polkadot flag	Pace on side of mailbox	Side of mailbox
Story 4	Yellow bag	Put next to Pooh	Next to Pooh
	Yellow crayon	Put in bag	In bag
	Block	Put in bag	In bag
	Blue hat	Put in bag	In bag

Table 2.

3-D Testing Stimuli

Story	Toys and Object Features
Farm Story	"Little People" figurine
	Animals: *yellow, plastic elephant*; Large plastic zebra; plastic eagle
	Food: *Plastic, yellow corn husk*; Plastic cheeseburger
	Plastic, red Lego car; Plastic blue Lego truck
	Fisher-Price Farm set: Including barn with opening doors and sliding roof top; silo with opening top
Make a Cake	Wooden, slightly raised, circle painted blue
	Red circular foam paper that equates the diameter of the wooden circle; blue circular foam paper
	Two white cotton balls with velcro; Two red cotton balls with velcro
	Wooden crown cut out; Wooden cupcake cut out, painted pink and white
	Beaded necklace, which equates the diameter of the "cake"; one green flowered lay, which equates diameter of "cake"
	Velcro adhesives to attach the pieces
Mail a Letter	*Red and white cooler* with a rectangular cut out on the side; Shoebox wrapped in gray paper with cut out on top
	Blue, three-dimensional rectangle used as the letter
	Small, yellow rectangular foam paper; Small, red triangular foam paper to represent the stamp
	Monkey sticker; lion sticker; both on red foam paper
	Red flag; Polka-dot flag. Both made from cloth and wooden chopsticks
	Velcro adhesives to attach the stamp and stickers
	Clear, purple container
First Day of School	*Blue, doll baseball hat*; Black doll dress hat
	Winnie the Pooh doll
	Two Crayola Crayons: *Yellow* and Brown
	Miniature toy block; Small pink and blue ball filled with beads
	Yellow plastic bag, Black gift bag

*Target objects are italicized.

Table 3.

Average Target Recall of 30-month-old Boys and Girls and 36-month-old Boys and Girls During Different Presentation Dimensions

Presentation Dimension	30-Month-Olds		36-Month-Olds	
	Boys	Girls	Boys	Girls
2-D	1.35	1.88	2.15	2.28
3-D	1.37	1.38	1.87	2.42

Table 4.

Pearson Correlation Values for Action Information

	Language Development			
Action Information	Sentence Usage	Language	Sentence Production	Vocabulary
Same Dimensions	0.614	0.588	0.496	0.492
Different Dimensions	0.611	0.614	0.562	0.498

*$p < .01$

Table 5.

Pearson Correlation Values for Location Information

	Language Development		
Location Information	Sentence Usage	Language	Vocabulary
Same Dimensions	0.625	0.548	0.484
Different Dimensions	0.587	0.587	0.461

*$p < .01$

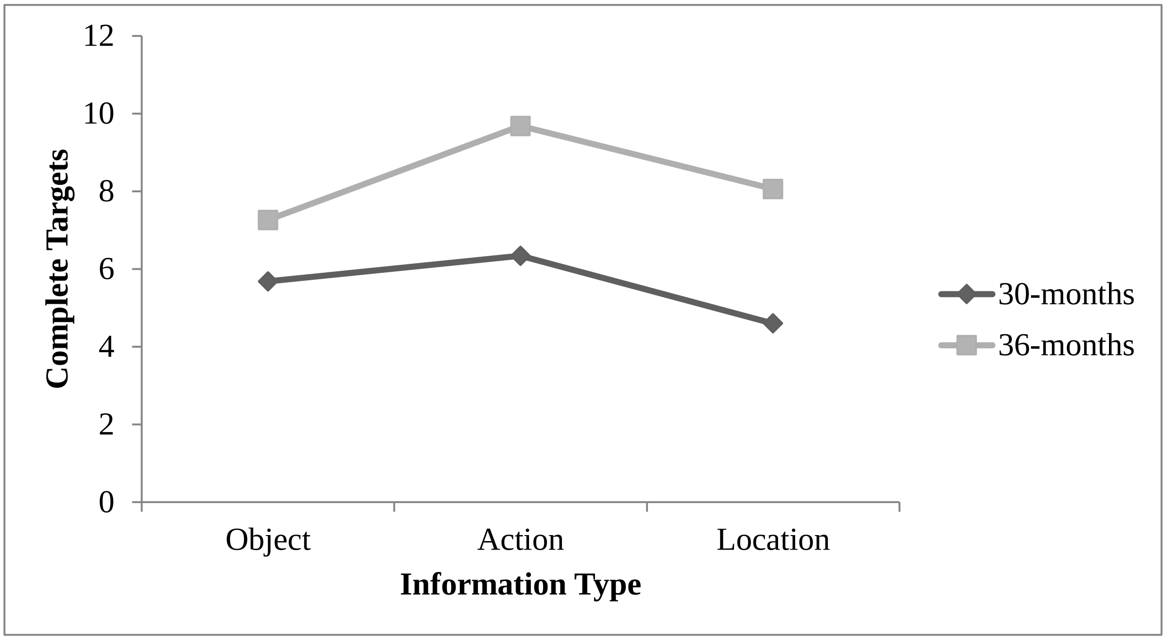


Figure 1. The figure illustrates a significant Age x Target interaction effect on children's overall recall of the targets presented in the four stories with older and younger children recalling more action information than object and location. In addition, the figure illustrates that 30-month-old children recalled more object than location information, whereas 36-month-old children recalled more location than object information.

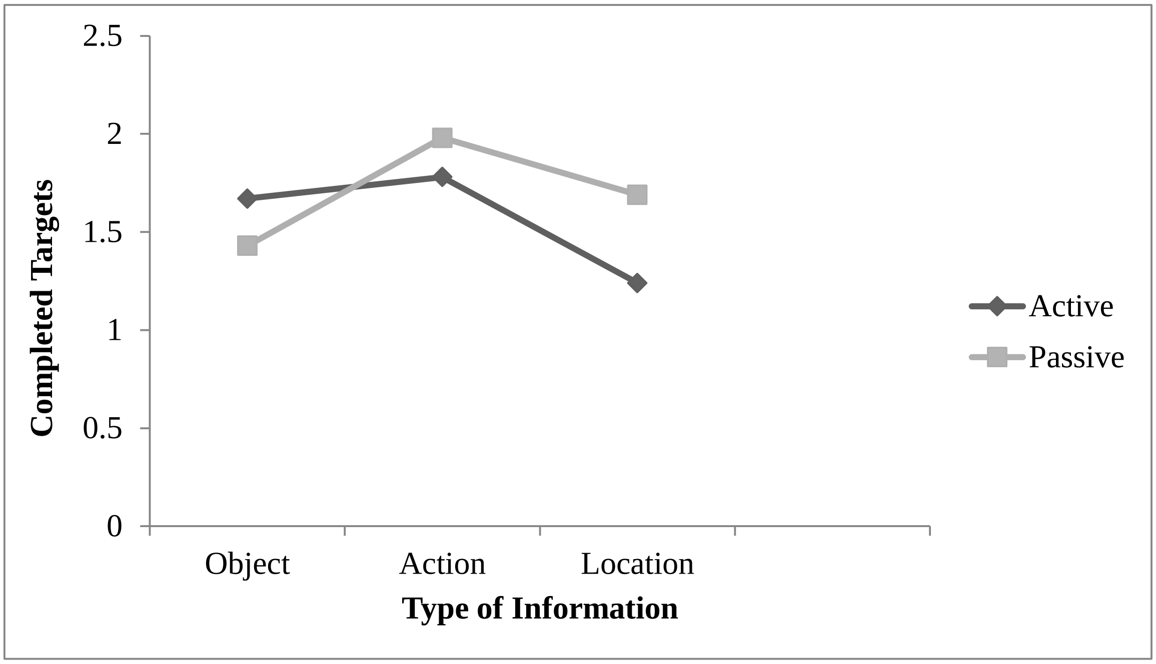


Figure 2. The figure illustrates the significant Activity Level x Target Type interaction effect on children's target recall when the presentation sessions and imitation tests occurred in opposite dimensions. The figure shows that children always recalled more action information whether passively watching or actively participating during the presentation sessions. However, children remembered more object information when they actively participated during the presentation and more location information when they passively watched during the presentation session.

Appendices

APPENDIX A: Farm Story

"This is Johnny (Hold up or point to Johnny). Johnny is going to spend the day at the farm today, but first he needs to find a way to get there. Johnny can either take the blue truck or the RED car (point to each as describing each). He decides to take the RED car. So he gets in the car and drives to the farm (put Johnny on car and "ride" to the farm). Once he gets to the farm, Johnny wants to play. He sees a pile of snow and a pile of SAND (point to each). Johnny decides to jump and play in the pile of SAND (Put Johnny on top of sand). After playing, Johnny decides that he wants to feed the zebra because the zebra loves food. While looking for some food, Johnny finds a cheeseburger and CORN (Hold and shake both the cheeseburger and corn). But, Johnny knows how much the zebra loves CORN. So Johnny takes the corn (take out corn) and feeds the corn to the zebra (Place corn next to zebra; "mmmm the zebra likes the corn"). After he feeds the zebra, Johnny remembers that the zebra has a best friend, but he doesn't know where he is. Johnny decides to check the silo (Open the lid of silo and pull out the elephant and eagle). Look! He found the ELEPHANT and an eagle. Johnny knows the elephant is the zebra's best friend so he puts the elephant with the zebra (Put the elephant next to the zebra; put eagle back in silo). Now the zebra and the elephant are very happy and Johnny feels happy too." The End.

APPENDIX B: Cake Story

"Minnie's birthday is coming up and Mickey has made a cake for Minnie. Now he needs to decorate it. Mickey needs to first choose which color icing to put on the cake. Mickey can choose the red icing or the blue icing (pick up both as saying each color). He decides to use the RED icing and puts the icing on the cake (Place large red circle on cake). After putting on the icing, Mickey wants to put some decorations on the cake, but he forgets where he put them. Then, he decides to check the container (Open container and hold up the red and white cotton balls). Look! He found red decorations (hold up) and WHITE (hold up) decorations. Mickey chooses the WHITE decorations (place white cotton balls on SIDES of cake) and he puts them on the sides of the cake. Now Mickey wants to add a special decoration for the center of the cake. And Look! He sees there a CROWN (hold up) and a cupcake (hold up). He chooses the CROWN and puts it on the center of the cake (place the crown in the center of the cake). Now the cake is almost ready for Minnie's birthday but Mickey wants to put something around the cake. Look! Mickey sees pretty green flowers or pretty GEMS (hold up both). Mickey decides to put the pretty GEMS around the cake (Place green one back and large beads around outside of cake). Now the cake is ready for Minnie's birthday!" The End!

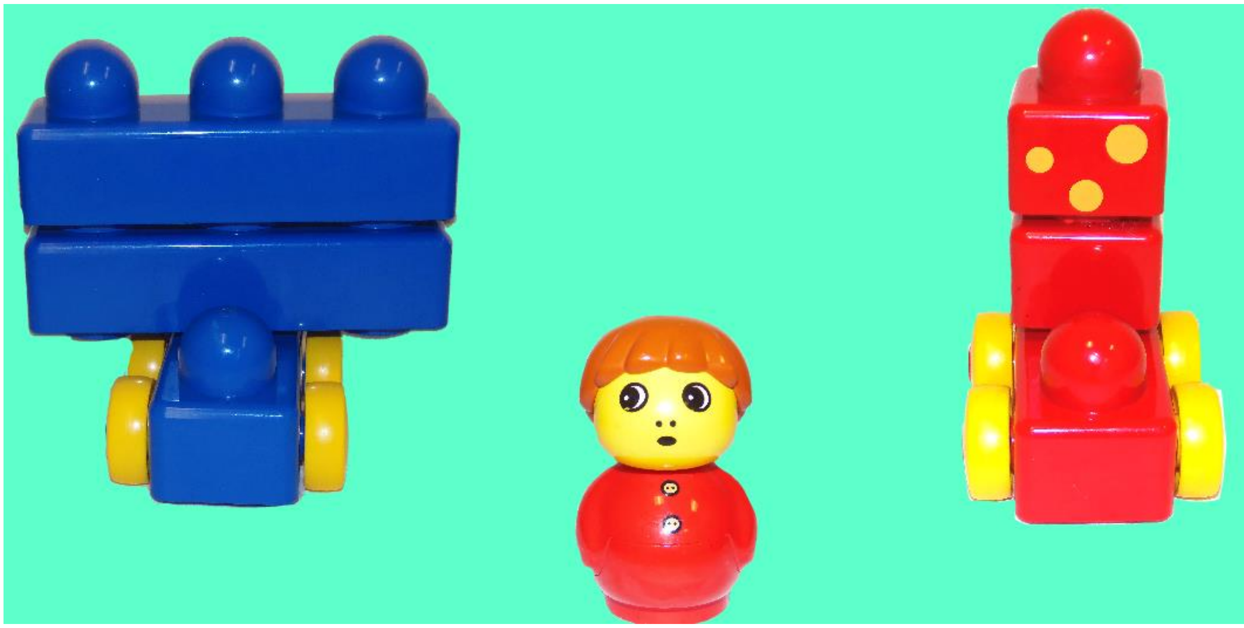
APPENDIX C: Letter Story

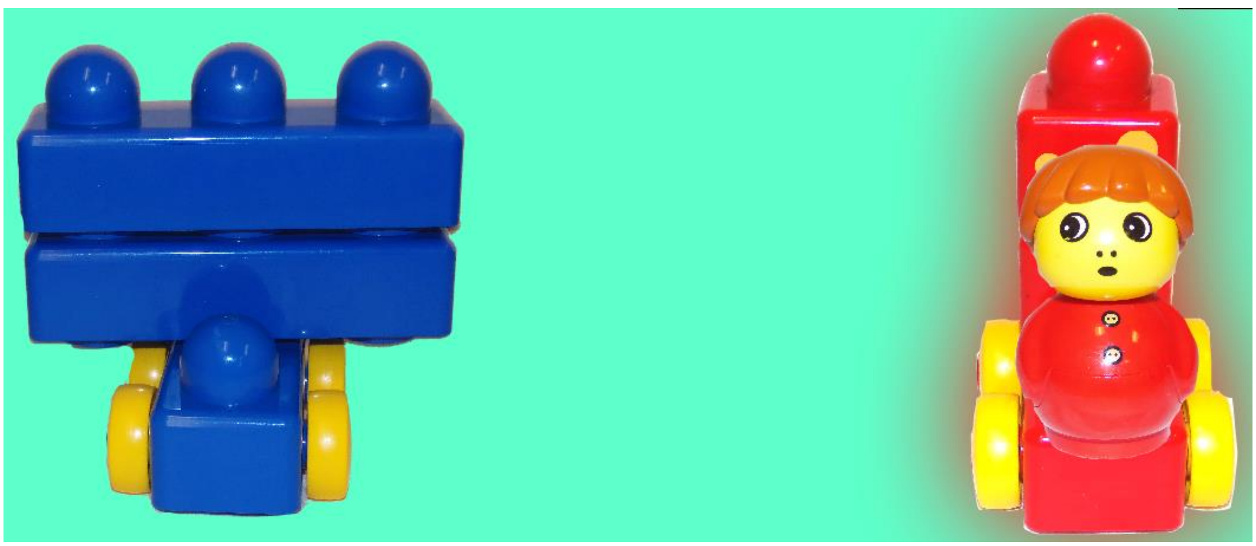
“This is Sally (hold up Sally) and Sally is mailing a letter to her friend Thomas. Sally has a big blue envelope for her letter (Hold up and shake envelope) but needs to do a couple of things before she can mail it. Sally first needs to put on a stamp. She sees that she has a RECTANGLE stamp and a triangle stamp. She decides to use the YELLOW stamp [put triangle stamp back] and puts it in the corner of the envelope (place sticker in corner). Next, Sally wants to add a sticker to the letter, but she forgets where she put them! She thinks she remembers seeing stickers in the purple container. So she checks the container, and look! (Open container, pull out BOTH stickers) There’s a MONKEY sticker and a tiger sticker. Sally chooses the MONKEY sticker and places it in the middle of the envelope (place sticker in middle of letter). Now Sally must put the letter in the right mailbox. She has a silver mailbox (point to shoebox) and a red and white mailbox (point to red mailbox). She decides to put the letter in the RED AND WHITE MAILBOX. (Place envelope in mailbox). Now the letter is almost ready, but Sally needs to put a flag on the side of the mailbox to let the mailman know there is a letter. She has a POLKADOT FLAG and a red flag. She decides to put the POLKADOT FLAG on the side of mailbox. Now, her letter is ready to be sent!” The End!

APPENDIX D: School Story

"Winnie the Pooh is getting ready for his first day of school, but before leaving he needs to pack a bag. First he needs to choose which bag to bring. He has a YELLOW bag and a black back (HOLD UP BOTH). He decides to bring the YELLOW bag to school and puts it next to himself (Hold up and put yellow bag next to Winnie). After choosing a bag, Winnie the Pooh wants to choose a crayon to bring to school. Look! He has a YELLOW crayon and a brown crayon (hold up both and show to child). He decides to bring the YELLOW crayon and puts the crayon in his bag. Next, he remembers that he wants to bring a toy for show and tell, but he doesn't remember where his toys are! Winnie the Pooh decides to check his toy chest (lift over red flap) and look! He found a ball and a BLOCK! He decides to bring the BLOCK for show and tell. Now, Winnie the Pooh is almost ready for school but wants to make sure he has a hat with him before he leaves. He sees his black hat and his BLUE hat. He decides to bring the BLUE hat and puts it in his bag. Now he is ready for his first day of school!" The End!

APPENDIX E: Target Information – Object, Action, Location





Object = Car (Red* or Blue)
Action = Place Johnny on car
Location = Place Johnny in correct location (Front* or Top)
**Correct object, action, or location*

APPENDIX F: CDI-III

The MacArthur Communication Development Inventory
Level III

Child's name:___________ Birthdate:_____ Today's Date______

VOCABULARY CHECKLIST

Children understand many more words than they say. We are particularly interested in the word your child SAYS. Please mark the words you have heard your child use. If your child uses a different pronunciation of the word, mark it anyway. This is only a sample of words: your child may know many other words not on this list. Please highlight each word your child can produce on the list.

- Dinosaur
- Donkey
- Reindeer
- Castle
- Drum
- Football
- Microscope
- Tricycle
- Kite
- Wagon
- Lemon
- Peanut
- Cracker
- Salt
- Sauce
- Vanilla
- Vegetable
- Beads
- Jeans
- Elbow
- Fingernail
- Thumb
- Bandaid/bandage
- Blade
- Computer
- Glass
- Jar
- Ladder
- Material
- Stamp
- Tire
- Furniture
- Kitchen
- Sofa/couch
- Cloud
- Fence
- Hose
- Sidewalk
- Zoo
- Child
- Cowboy
- Family
- Farmer
- Nobody
- Nurse
- Accident
- Circle
- Front
- Idea
- Camping
- Catch
- Drop
- Fasten
- Forget/forgot
- Hate
- Hurry
- Leave
- Measure
- Peel
- Promise
- Skate
- Sneeze
- Somersault
- Think
- Black
- Bored
- Deep
- Different
- Empty
- Expensive
- Fine
- Half
- Long
- Lost
- Angry
- Peculiar
- Before
- Then
- Today
- Week
- Yesterday
- Their
- They
- Those
- Yourself
- Why
- About
- Above
- Away
- Between
- On top of
- Each
- Every
- None
- Might
- Need to
- Were
- Although
- Because
- However

Has your child begun to combine words yet, such as "nother cookie" or "doggie bite?" Please highlight which choice best describes your child.

- Not Yet
- Sometimes
- Often

If you answered "Not Yet", please stop here. If "Sometimes" or "Often", please continue.

Sentences

For each pair of sentences below, highlight the one that sounds MOST like the way your child talks at the moment. If your child is saying sentences even more complicated than the two provided, mark the second one

1. (Talking about something that already happened)
   Daddy pick me up **OR** Daddy picked me up
2. That my truck **OR** That's my truck.
3. Coffee hot **OR** That coffee hot
4. I like read stories **OR** I like to read stories
5. Don't read book **OR** Don't want you read that book
6. Why he run away? **OR** Why did he run away?
7. He did it **OR** I know who did it
8. We got to go now **OR** I think we got to go now
9. I want truck **OR** I want truck like Tommie has
10. This dolly big **OR** This dolly big and this dolly little
11. This pig have a broken leg **OR** This pig have a broken leg but kitty don't
12. It got broken **OR** It got broken by the car

Using Language – Please highlight either "YES" or "NO" to each question.

1. Does your child understand the concept of "one"? If you ask for just one (cookie, strawberry, etc.) will your child give you only one and then stop?

   YES or **NO**

2. Does your child ask questions with more than one word that begin "what" or "where"

   YES or **NO**

3. Does your child ask questions with more than one word that being "why" or "how"?

   YES or **NO**

4. Does your child give reasons for things, using the word "because"?

   YES or **NO**

5. If you asked your child "What is a horse?", could they answer "an animal"?

   YES or **NO**

6. Can your child name simple shapes with the words "circle", "square" and "triangle"?

   YES or **NO**

7. Does your child talk about things that "could" or "might" happen, such as "he could hurt himself if he's not careful"?

   YES or **NO**

8. Does your child ever ask what a particular word means?

   YES or **NO**

9. Could your child tell you which of two objects is larger if they were not present, for example "which is bigger a horse or a dog?"

   YES or **NO**

10. Does your child know his/her right hand from his/her left hand?

    YES or **NO**

11. Does your child use –est words such as "biggest" and "strongest"?

    YES or **NO**

12. Can your child answer questions such as "what do you do when you are hungry?" and "what do you do when you are tired?," with appropriate answers such as "get food," "eat," "go to sleep," and/or "take a nap"?

    YES or **NO**

Examples: Please list THREE of the longest sentences you have heard your child say recently.

1.

2.

3.

APPENDIX G: Parent Media Survey

Parent Media Survey

The Parent Media Survey will ask a series of questions about your child's exposure to different types of media, as well as some questions about your child's daily activities. For YES or NO, or multiple choice questions, please highlight your response. For fill-in-the-blank questions, please type in your response. If you have questions, please call the Cognitive Development Lab at (410) 704-5873.

1. Does your child watch television/DVDs? YES or NO
   a. If so, about how many hours per day does your child watch TV? _______
   b. (If YES) How much time does your child spend watching:
      i. Educational content? ________
      ii. Entertainment content? _________

2. Does your child use a computer (laptop or desktop)? YES or NO
   a. If so, about how many hours per day does your child use a computer? _______
   b. (If YES) How much time does your child spend watching:
      i. Educational Computer Games (math or reading games)? _______
      ii. Entertainment Computer Games? _______
      iii. Other (i.e., goofing around, hitting buttons randomly) ______

3. Does your child use any touch-screen devices (i.e., Tablets, iPad, iPhones, etc)? YES or NO
   a. If so, about how many hours per day does your child use a touch-screen device? _________
   b. (If Yes) How much time, on average, does your child spend using the device for:
      i. Educational purposes (reading/writing/etc)? ______
      ii. Entertainment purposes (e.g., Angry birds)? ______
      iii. Videos/TV shows? ______
      iv. Other (i.e., goofing around, hitting buttons randomly, stealing mom's phone, etc.)_____

4. Please tell me if you have any rules for your child about each of the following:
   Do you have any rules about:
   a. What your child can or cannot watch on TV/DVD?
      i. YES or NO
   b. How much time your child can spend watching TV? YES or NO
   c. How much time your child can spend on the computer (if applicable)?
      i. YES or NO
   d. What your child can or cannot do on a touch-screen device (if applicable)?
      i. YES or NO

    e. How much time your child can spend on a touch-screen device (if applicable)?
        i. YES or NO

5. How much time did your child spend (INSERT) this past week(?):
    a. Playing outside: ________
    b. Reading or being read to: ________
    c. Playing inside with toys: _________

6. When you're at home with your child and you have something important to do, how likely are you to sit with (him/her) down with a video or TV show while you get it done?
    a. Very Likely
    b. Somewhat likely
    c. Not at all likely
    d. No TV in household

7. When your child is playing and the TV is on in the background, how frequently does it distract (his/her) attention from what (he/she) is doing? Does this happen:
    a. Often
    b. Sometimes
    c. Never
    d. No TV in household

8. Please tell me if your child has EVER done each of the following things. Has your child ever:
    a. Used a computer WITHOUT sitting on a parent's lap? YES or NO
    b. Turn on a computer by themselves? YES or NO
    c. Used a mouse to point and click? YES or NO
    d. Used a touch-screen device by themselves? YES or NO

9. Please tell me at what age did you child first do each of the following things?
    a. Watch TV? > 6 mo 6-11 mo 1 yr 2 yr 3 yr
    b. Watch a video or DVD? > 6 mo 6-11 mo 1 yr 2 yr 3 yr
    c. Use a computer? > 6 mo 6-11 mo 1 yr 2 yr 3 yr
    d. Use a touch screen device? > 6 mo 6-11 mo 1 yr 2 yr 3 yr

10. Does your child recognize any letters? YES or NO

11. Does your child recognize his name in print? YES or NO

12. Does your child know how to read? YES or NO

13. In general, do you think (INSERT OPTION) mostly helps or mostly hurts children's learning – or doesn't have much effect either way?

a. Watching TV: Mostly helps Mostly hurts Not much effect
b. Using a computer: Mostly helps Mostly hurts Not much effect
c. Playing video games: Mostly helps Mostly hurts Not much effect
d. Using touch-screen devices: Mostly helps Mostly hurts Not much effect

14. Does (NAME) have any siblings? YES or NO
    a. If so, is your child the:
        i. Youngest ____
        ii. Middle ____
        iii. Oldest ____

15. Please tell me how important, if at all, you think each of the following is in helping the intellectual development of children who are your child's age. Please respond with Very important, somewhat important, not too important, not at all important, or don't know. How important is:
    a. Reading Books? ________
    b. Building toys like blocks/Legos? ________
    c. Doing puzzles? _________
    d. Using educational toys like talking books? ___________
    e. Watching educational TV shows like "Sesame Street"? ___________
    f. Watching educational videos or DVDs? _____________
    g. Playing educational computer/touch-screen games? ____________
    h. Visiting educational websites? ___________

Appendix H: IRB Approval Form

TOWSON UNIVERSITY

Date: Thursday, February 07, 2013

NOTICE OF APPROVAL

TO: Elizabeth Moore **DEPT:** PSYC

PROJECT TITLE: *Learning from a screen: The effects of screen orientation and contingent interactions on preschool children's memory*

SPONSORING AGENCY:

APPROVAL NUMBER: 13-A035

The Institutional Review Board for the Protection of Human Participants has approved the project described above. Approval was based on the descriptive material and procedures you submitted for review. Should any changes be made in your procedures, or if you should encounter any new risks, reactions, injuries, or deaths of persons as participants, you must notify the Board.

A consent form: [✓] is [ ] is not required of each participant

Assent: [✓] is [ ] is not required of each participant

This protocol was first approved on: 07-Feb-2013

This research will be reviewed every year from the date of first approval.

Debi Gartland

Debi Gartland, Chair

Towson University Institutional Review Board

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Curriculum Vita

Elizabeth Moore

[redacted]

Education

Towson University, Towson, MD
M.A. in Experimental Psychology **2014**
Thesis: Learning From a Screen: Can Interactive Devices Improve Children's Memory for Symbolic Media Representations?

Bloomsburg University, Bloomsburg, PA
B.A. in Liberal Arts **2012**

Academic Honors

Graduate Student Research Award, $500, 2013
Phi Kappa Phi, 2012
Psi Chi, 2012

Research Experience

Research Assistant **2012-2014**
Towson University's Captioning Solutions
Training Director
Voicewriter/Editor/Transcriber
Cognitive Development Lab **2013-2014**
Lab Manager
Independent Study at Bloomsburg University, supervised by Dr. Jennifer Johnson **2011**
Research focused on behaviorally measuring cross-modal deactivations in the auditory and visual modalities. Measured participants' reaction times during cognitively high-load and low-load visual and auditory tasks