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CHILDREN'S LETTER LEARNING: THE EFFECT OF MANIPULATING VISUAL COMPLEXITY ON CHILDREN'S LETTER LEARNING

Bahar Amani
aman3590@mylaurier.ca

Children's Letter Learning: The Effect of Manipulating Visual Complexity on Children's Letter Learning

Bahar Amani

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Abstract

As a growing presence in homes and schools, technology plays an important role in the way that children learn in their environment. The early integration of technology within education reflects the promise of computer-based educational tools to facilitate early learning in children (Grant, Wood, Gottardo, Evans, Phillips, & Savage, 2012). Young learners are reported to be challenged with high levels of distractibility that can hinder their ability to learn in particular conditions and contexts (Fisher, Godwin, & Seltman, 2014). This can be a problem when considering that educational materials are often designed to be elaborate to keep young learners interested. For this reason, the present study sought to determine the effect of visually "busy" versus visually "simpler" backgrounds during a video presentation meant to encourage the development of alphabetic knowledge. The participants recruited for this study included 20 preschoolers, 20 children in grade two, and 32 undergraduate students. Participants were presented with unfamiliar letter shapes (Arabic and Hebrew letters) in each of the two video contexts (busy and simpler). In order to test for differences in information retention and possible learning between the two displays, a forced-choice recognition task was used to compare between the two types of screens. To take into account individual differences, participants or their parents completed family literacy and technology use questionnaires, as well as were evaluated on literacy and vocabulary measures. Analyses included correlational analysis, descriptive statistics and multivariate analyses of variance. There was a main effect of age on performance overall. However, there were no significant differences between performance on the simpler and busy conditions for each age group. Lastly, literacy skill, vocabulary skill and technology use did not show significant relationships with performance on the letter learning task.

Keywords: education, technology, media, attention, distractibility

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Today's children are being raised in a rapidly changing technological environment. This cultural shift has been met by the attempts of educators, policy makers and software developers to provide students with computer and media-based learning tools that are engaging and promote learning (Kong et al., 2014). When integrating technology into education as a tool for learning, it is important to consider the fact that young children have a high level of distractibility that can affect how they learn in particular conditions and contexts (Fisher, Godwin, & Seltman, 2014). A large body of research has demonstrated that focused attention is pivotal in learning throughout life (Fisher et al., 2014; Fisher, Thiessen, Godwin, Kloos, & Dickerson, 2013; Gaertner, Spinrad, & Eisenberg, 2008; McKinney, Mason, Perkerson, & Clifford, 1975; Oakes, Kannass, & Shaddy, 2002; Ruff & Rothbart, 2001; Yu & Smith, 2012). Educational videos, games, and even text media are designed to be visually engaging but are often busy, meaning that they include a lot of pictures and animation. These features may or may not be relevant to the learning task. Busy visual media displays may be problematic for young learners because they have not developed the necessary attentional mechanisms to allow them to focus only on important or relevant information (Colombo & Cheatham, 2006; Kane & Engle, 2002; Ruff & Rothbart, 2001). In the case of this study, the "busy" visual display is characterized as having irrelevant and dynamic visual features. The busy display is contrasted with the "simple" display, with fewer visual features, all of which are static. To determine the influence of a visually busy versus a visually simple screen display on learning, the present study presented participants with videos containing unfamiliar letter shapes (Arabic and Hebrew letters) in each of these two contexts, specifically simple and busy. Memory for information presented in each of these short videos was tested. Participants of three age groups: preschoolers (age 2-3 years), grade two students (age 7 years) and undergraduates (age 18 years) were used to examine the impact of age on the learners' susceptibility to visual distractions on the screen.

Roadmap

The following sections will review a key idea in child development research: sensitive periods of development, and suggest the role that experiences during sensitive periods can have on later learning. Related to this, there will be a discussion on attention in young children, with a strong focus on the development of inhibitory processes and executive functioning. These processes are expected to influence learning as attention to stimuli is a crucial first step to learning, and executive functioning is a component of memory. Next, the impact of technology and media will be discussed as well as the use of previously mentioned research on attention as a framework for understanding the relationship between technology and education, specifically reading acquisition.

Sensitive Periods of Development

The rise in the availability of technology and media forces us to consider how early media use might influence child development. This question has increasingly become the subject of academic discussion and public policy concerns ("Impact of media use on children and youth", 2003; Brown, 2011). When the effect of experience is very strong during a particular period in an individual's development, this period of time is called a sensitive period (Knudsen, 2004). Young children are particularly susceptible to the influence of their environment, so experiences and exposure to stimuli can have strong and lifelong effects on their development (Knudsen, 2004).

These developmental windows of time however, are not only confined to infancy and childhood. Sensitive periods have demonstrated their presence throughout infancy and adolescence (Penhune & De Villers-Sidani, 2014; Fuhrmann, Knoll, & Blakemore, 2015). For example, an important period for the development of visual acuity is typically in the first seven years of life (Fuhrmann, Knoll, & Blakemore, 2015; Maurer & Lewis, 2013), whereas emotional facial recognition has been speculated to continue to develop during adolescence (Thomas, De Bellis, Graham, & LaBar, 2007). Figure 1 presents the above-mentioned developmental events, as well as key attentional and memory-related developmental events in the form of a timeline to help visualize the time-dependent component of these periods. The participants in the present study were selected based on their experience with learning alphabetic symbols, with preschoolers having little experience with and knowledge of alphabetic symbols, and university students showing the highest level of experience with these skills, ideally representing optimal performance.

Sensitive Periods and Later Learning

Sensitive periods provide a window of time where specific brain regions are at an optimal period of development (Knudsen, 2004). As the early years of life are important for development generally, the emergence of technology and media undoubtedly has the potential to influence the development of executive functions and related mechanisms such as attention, memory and learning.

The Development of Executive Functioning

Broadly defined, executive functions are a set of cognitive processes that are necessary for higher order mental functioning and make goal-directed behaviour possible (Logue & Gould, 2014; Best & Miller, 2010; Baddeley, 1998; Robbins, 1996; Stuss & Alexander, 2000). Although the complexity of executive functioning makes it difficult to operationalize, its components can be separated and measured (Fletcher, 1996). Fletcher (1996) explains that executive functions represent several different aspects of cognition, including the distribution of cognitive resources, planning, response inhibition and regulation. The nature of these processes suggests the important role they play within the framework of working memory (Fletcher, 1996; Pennington, 1994). In addition to working memory, some notable foundational components of executive functions include, but are not limited to, attention, cognitive flexibility, and impulse control (Best & Miller, 2010). The normal and abnormal development of executive functions in children has been studied extensively over the last three decades (Isquith et al, 2004; Fletcher, 1996; Passler, Isaac, & Hynd, 1985; Welsh, Pennington, & Grossier, 1991).

Developmental Trajectories of Executive Functions

In 1991, Welsh et al. evaluated participants, ranging from three to twelve years of age, using a set of clinical neuropsychology and developmental psychology measures that assessed executive function. In addition to the three to twelve year old participants, an adult group was tested for comparison. Some examples of the measures used to assess executive functions include the Wisconsin Card Sorting Task (WCST), a visual search task, and a recognition memory task. The visual search task timed children while they searched for target items among a group of distractors. The score for this assessment was calculated by dividing the response time by the number of correct responses. The next measure, the WCST, developed by Grant and Berg (1948), is a task where participants are presented a series of cards that contain stimuli of varying color, shape and form. Participants are told to sort the cards by matching the cards with a key card that has the same characteristic, for example, shape. Performance on this task depends on cognitive flexibility and switching sorting strategies when the examiner switches to a new sorting principle, such as colour. The third measure used was a continuous picture-recognition task, developed by Brown and Scott (1971). Participants are presented with a set of 100 cards with pictures on them one at a time. Some of the cards have repeated pictures. Participants are asked whether the picture on the card they are seeing was repeated. A score is determined based on the number of correct responses out of 100.

After testing participants using these measures, Welsh et al. (1991) found that there are different developmental trajectories for different tasks, which suggests that various aspects of executive functions develop at different times. An especially notable finding was that visual search efficiency at 6 years old was very similar to adult performance, demonstrating an ability to resist distractions at a young age. In addition, at age 10, performance on the WCST was equivalent to adult levels, and at age 4 performances on the recognition memory task reached adult levels of performance. Similarly to these results, Passler et al. (1985) found that the development of behaviours associated with frontal lobe functioning, or the executive functions, show the greatest period of development between six and eight years of age and by 10 years of age children are thought to possess the ability to successfully inhibit attention to irrelevant stimuli (Figure 1).

Following the research by Welsh et al. (1991) and Passler et al. (1985), recent literature supports the idea that different subcomponents of executive functions develop during specific timeframes of rapid development (Schiebener, García-Arias, García-Villamisar, Cabanyes-Truffino, & Brand, 2015; Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001; Best & Miller, 2010; Best, Miller, & Jones, 2009; Jurado & Rosselli, 2007; Romine & Reynolds, 2005). For example, the precursors to attentional control, attention allocation and inhibition, demonstrate a developmental spurt during eight to nine years of age (Schiebener et al., 2015; Figure 1). By age eleven or twelve, individuals demonstrate adult level abilities in attentional control (Brocki & Bohlin, 2004; Romine & Reynolds, 2005; Figure 1). These attentional resources and components of executive function are required when learning specific items in distracting situations such as the “busy” condition in the present study.

Early Appearance of Executive Functions

There is a large body of research focused on understanding the structure, organization and development of executive functions in infants and preschool age children. Although fully developed executive functions may not be visible in preschool populations, the early precursors of executive regulation can be measured and described (Isquith et al., 2004). In support of this, many early papers demonstrated that attentional control and future-oriented, intentional problem solving are thought to begin during infancy and continue through the preschool years (Diamond, 1985; Haith, Hazan, & Goodman, 1988; Espy, Kaufmann, McDiarmid, & Glisky, 1999; Welsh et al., 1991; Figure 1). For example, Haith et al. (1988) demonstrated that 3.5 month olds have the cognitive capacity to develop expectations for a series of predictable visual events that are independent of their control. The 3.5 month olds produced faster reaction times and anticipatory fixations for a series of visual events that were designed to have some predictability. In the current study, the preschool group and the second grade group were expected to show differences in executive function, as were the second grade group and the university group. Although executive function measures are not administered in the study, the key task is expected to require executive function.

Attention and Visual Selectivity

Attention is notably one of the most complex cognitive functions because it serves many different purposes and is composed of a variety of neural and behavioural processes (Fisher, Thiessen, Godwin, Kloos, & Dickerson, 2013; Colombo & Cheatham, 2006; Kahneman 1973; Posner & Petersen, 1990; Posner & Rothbart, 2007). Some functions of attention include orienting, selecting appropriate information to attend to, and maintaining and sustaining attention when distracting stimuli are present (Fisher et al., 2013; Colombo & Cheatham, 2006; Kahneman 1973; Posner & Petersen, 1990; Posner & Rothbart, 2007).

The Components of Visual Selectivity

The three important components of visual selectivity are search, filtering and priming (Enns & Cameron, 1987). The first factor, search, refers to the changes in attention in a visual space. Second, filtering involves ignoring unnecessary stimuli or attributes in the visual field to allow for a relevant stimulus to be processed. Lastly, priming refers to maintaining or changing cognitive strategies over time. These three mechanisms, search, filtering and priming, work together to allow an individual to successfully, visually select what they attend to in their environment with filtering being the mechanism required for the key task in the current study.

As infants develop into toddlers they become more systematic in the way that they attend to stimuli in memory related tasks (Ruff & Rothbart, 2001; Baker-ward, Ornstein, & Holden, 1984; Miller, 1990). In the first year of life, investigative and orienting systems are in control of selective visual attention, allowing for novelty to play a substantial role in governing attention (Ruff & Rothbart, 2001). After this first year, a higher level system takes control allowing for more intentional attention (Ruff & Rothbart, 2001).

Examples of Attentional Control in Different Age Groups

A classic study by Vurpillot (1968) looked at the visual search strategies used by children in a same-different picture comparison task by video recording their eye movements. The study found that older children looked less at irrelevant information than the younger children, suggesting that age led to improved visual search strategies. Two years later, Mackworth and Bruner (1970) recorded the eye fixations of 7-year-old children and adults while they looked at a series of pictures of the same scene. They were presented with a very blurred, blurred, and then a sharp image or presented with the same photos in the opposite order. Each photo was presented twice for ten-second trials. When sharp images were presented, children were unable to fixate on as much of the display as the adults because of their smaller eye movements making it difficult for them to adequately cover the display. Adults were also better able to fixate their eyes on the telling parts of the displays when the photos were blurred. These studies demonstrate the disadvantage that children have when compared to adults performing tasks that require higher-level visual and perceptual abilities.

Attention and Distractibility in Young Children

When designing learning material for young children, it is paramount that the stimuli are developed with the specific age group of the audience in mind. Young children have a high level of distractibility, which can hinder their ability to learn in particular conditions and contexts (Fisher, Godwin, & Seltman, 2014). Although this is true for young learners, for some reason, there is a paradoxical relationship in the “real world” between age and typical classroom design. Often, young children who demonstrate poor regulation of attention are put in distracting environments and situations. For example, a study by Fisher et al. (2014) found that when kindergarten children were taught science lessons in a highly decorated classroom, they spent more time off-task and had considerably smaller learning gains than when the decorations were removed from the walls. The importance of facilitating focused attention for young children is demonstrated by the children’s lower performance when learning occurred in a decorated room. Visual distractions in the children’s larger scale environment had a negative impact on their ability to learn material, which suggests that visual distractions directly in a child’s focal view can have a negative effect on their learning. To illustrate, Chiong and DeLoache (2012) demonstrated that children performed better on a letter learning task when they read simple ABC books, compared to children who read highly decorated ABC books with more visual and physically manipulative features. The present study extends this research and examines these visual features in a video and active context. By presenting participants with two videos of varying levels of "decoration" on screen, we are exploring whether we would see a similar outcome as the classroom and ABC book study.

Distractibility and Prior Knowledge to Material

A study by Evans and Saint-Aubin (2013) had children look at storybooks and then examined their attention to illustrations and text while they listened to storybooks read aloud to them. Eye-tracking information was noted while they looked at storybooks that were presented to them on computer screens. Researchers found that reading skill level predicted attention to print, and that in terms of illustrations, children paid attention to the illustrations in conjunction with the spoken text, as young children have a natural tendency to attend to pictures (Evans & Saint-Aubin, 2013; Samuels, Biesbrock, & Terry, 1974).

Young children exposed to media are constantly viewing a series of rapidly changing images. This makes it necessary for young viewers to reorient in order to focus on the continuous novel stimuli they see on the screens (Christakis, Zimmerman, DiGiuseppe, & McCarty, 2004). Continuously having to elicit an orienting response and shift their focus prevents young children from taking part in sustained attention. This inability to sustain attention in turn has a negative effect on their attention span (Christakis et al., 2004; Singer, 1980).

Using older participants, a recent study by Magner et al. (2014) sought to determine whether relevant decorative illustrations could both foster and hinder learning among grade 8 students in a computer-based learning environment. This study included 52 students who were tested to see if decorative illustrations during a lesson meant to teach geometry had an influence on immediate learning outcomes and enhanced further learning on the subject. Geometry learning was distinguished by near and far transfer learning (Macaulay & Cree, 2000). Near transfer of learning is when knowledge learned can be used for situations that are the same, whereas far transfer of learning is when new knowledge can be used in different situations (Macaulay & Cree, 2000). Magner at al. (2014) found that the decorative illustrations had a negative effect on near transfer when students had low prior knowledge of the material. However, students with more knowledge of the material actually benefited from the decorative illustrations. There was no overall effect found in far transfer but decorative illustrations indirectly influenced far transfer performance through increased interest in the lesson and task. The study demonstrated that although the learning material included relevant visuals, these visuals were only of benefit to those who were already knowledgeable about the subject in terms of near transfer performance.

Developmental Differences in Attention Selection and Learning

The ability to attend selectively to critical stimulus features and ignore irrelevant ones is a crucial part of learning (Wolff, 1965). As mentioned earlier, a filtering mechanism is hypothesized to decide what information is attended to and what is ignored (Broadbent, 1958; Enns & Cameron, 1987). Broadbent (1958) suggested that young children`s struggle with filtering stimuli is a result of their inability to analyze stimuli in parts, instead viewing stimuli as one solid unit.

The literature mentioned above supports the idea that visually complex presentation can be problematic for young viewers because they have not developed the ability to appropriately filter visual stimuli and analyze what they see in its separate components. In contrast, adults who are presented a piece of information on a screen while there are also irrelevant images or text present, will be able to decide which specific part they will attend to on the screen, and easily switch back and forth between different components. These developmental differences in visual behaviour demonstrate the sensitive nature of young children's experience when viewing videos and other visual content. The current study presented videos with irrelevant and potentially distracting, visual stimuli to participants of three age groups to try to manipulate performance between groups and between types of stimuli, busy and simple. If the developmental differences in visual selection are observable, we would expect the child participants to struggle during the letter recognition memory task after viewing the busy video compared to the adult participants. Adult participants are expected to be able to break apart the different components of the video, the background, letter being presented and any animated and static objects, and focus on the component crucial to performance on the task, which is the letter being presented in that moment. In contrast, the child participants would view the video as a whole unit, which can prevent them from focusing in on the letter being presented.

Attention and Memory

Focused attention is crucial for optimal performance during lessons and tasks. With age, the developmental decrease in distractibility is attributed to developmental improvements in inhibitory control and working memory. Memory changes are proposed to occur closely with the emergence of voluntary attention, thus the relation between memory and attention is considered to be a reciprocal one (Colombo & Cheatham, 2006). Without focused attention to a stimulus, an individual would be unable to establish an enduring memory trace (Colombo & Cheatham, 2006). As mentioned earlier, research has demonstrated that from infancy to early childhood, around ages 5-6, children become significantly more methodical in attention deployment during memory-related tasks (Baker-ward, Ornstein, & Holden, 1984; Figure 1).

The Emergence of Technology and its Influence on Child Development

The growing presence of technology in the homes and schools of children in North America has given technology a principal role in influencing the mechanisms through which children can interact and learn from their environment (Lauricella, Wartella, & Rideout, 2015; Wartella & Robb, 2007; Vandewater, Rideout, Wartella, Huang, Lee, & Shim, 2007). The transition of technology and media devices from a luxury item, into a staple in the home and school continues to have a significant impact on children; technology and media devices have demonstrated their influence on learning, socialization, and culture (Teo, 2016). With the growing integration of technology, educators are challenged with the task of keeping up with advances in technology and media to ensure that they are presenting their students with information in a format that students find both relevant and engaging (Kong et al., 2014).

An Increase in Technology and Media Exposure in the Home

Approximately ten years ago, 61 % of children ages one and younger, and 88 % of children ages two or three were regularly exposed to screen media, which includes TV, videos, DVDs, computers and video games (Hamel & Rideout, 2006). In 2011, 90% of parents reported that their children two years old and younger watch some sort of media and by the age of three almost one-third of children have a television in their bedroom (Brown, 2011). More recently, it has been reported that 96% of families have at least one television at home and 36% of children age 8 and under have a television in their bedroom (Lauricella, Wartella, & Rideout, 2015). As a mediator between the child and the environment they are exposed to, parents play a key role in determining their child’s exposure to these forms of entertainment and learning aids.

The presence of screen media has become a familiar part of the background environment in many homes (Wartella & Robb, 2007). Parents report that a television is on in their home at least six hours a day (Brown, 2011). The statistics suggest that technology is an undeniably important aspect of the home environment and parents are not opposed to having technologies readily available to their children.

Young Learners as Digital Natives in the Current Era

The potential methods of teaching and learning are significantly different from those a few decades ago. The emergence of technology in the regular classroom has had a large role in the nature of educational practices and experiences, and learning in the present day classroom. New technology is developing so rapidly that it becomes difficult to infer the benefits and challenges of these advancements on the development of young children's attention and learning. Individuals born in or after 1980 are referred to as digital natives because they have been exposed to technology since birth (Prensky, 2001). Prensky (2001) suggests that as a result, certain aspects of their cognition may differ in their development as compared to previous generations. He claims that digital natives have developed greater cognitive abilities and that they process information very differently. With this in mind, it becomes important to consider that the emergence of mobile technology in the last decade has led to a divide between children and young adults today who, under Prensky's definition would both be considered digital natives. The release of the iPad in 2010 (Waters, 2010) was followed by a dramatic change in the way that parents would entertain their infants and children. This modern day phenomenon adds another dimension in the pursuit of understanding how young children learn in order to better serve them. Early exposure to mobile technology could possibly provide children with an advantage in learning from media that is heavily visually stimulating, so that their natural distractibility does not have as obvious an effect. This suggests that today's children can potentially persist in the face of heavy visual stimulation despite the concerns of educators and researchers.

Integrating Technology and Media into Education

Software programs and media that have been designed for educational use have shown promise in terms of the ability of computer-based learning to facilitate early learning in children (Grant et al., 2012). Learning interventions in the form of computer-based educational games continue to be created to promote the development of a wide range of skills in core subjects like science, math and language (Tamim, Bernard, Borokhovski, Abrami, & Schmidt, 2011; Grant et al., 2012). To illustrate, one study included a randomized control trial that examined the effects of a media-rich learning intervention on the literacy of young learners. The researchers found that children who received the media-rich literacy supplemental instruction showed greater improvement in letter recognition, phonics, and print and story concepts as compared to their peers who were not exposed to the literacy supplement (Penuel et al., 2012). Goldin et al. (2014) demonstrated that the availability of well-crafted educational games on laptops can promote school readiness in processes including attention, problem solving, and reading in children living in poor and rural Argentina. This research suggests that children can benefit from the use of computers and media if they are designed in a way that promotes the young learner's attention and learning.

Cognitive Theory of Multimedia Learning

The term cognitive load is an element of Sweller's (1988, 1994) cognitive load theory that explains that working memory has a limited capacity and cognitive load refers to the total effort being used by working memory. Sweller believed that thoughtful instructional design could alleviate any difficulties in learning that are a result of high cognitive load. When in their early years of school, young children are learning new information for the first time with little or no prior knowledge. For this reason, the design of educational materials is crucial to their learning experiences. The cognitive theory of multimedia learning is based on the premise that in media rich contexts there are dual channels of processing, each channel has a limited capacity and active learning happens with a coordinated set of processes during learning (Mayer & Moreno, 2002). Essentially, people learn more from words and pictures than just words alone. Mayer (1997) demonstrated that there was a multimedia effect with students who received a visual explanation with a verbal explanation, performing better on a problem-solving task than students who received only a verbal explanation. Mayer and Moreno (2002) encouraged the use of visual forms of presentation because learners exposed to material in verbal and pictoral form, including static images and dynamic materials (video and animation), demonstrated improved understanding as opposed to only being exposed to verbal forms of presentation. Animation can enhance the experience of the learner if the media is designed with the cognitive theory of multimedia learning in mind (Mayer & Moreno, 2002).

Relatedly, Clark and Mayer (2016) discuss the coherence principle, which explains that to promote learning and prevent an overwhelming cognitive load, designers should avoid using design features that are not directly related to the material being instructed. For viewers who are more knowledgeable however, these extra features like narrated animation might have the opposite effect and keep learners engaged (Clark & Mayer, 2016).

Reading and Early Literacy Development

Without a doubt, reading is a skill essential to determining the trajectory of young children’s academic performance. One of the first things taught in schools are alphabetic letters, because of the important role they play in alphabetic literacy acquisition (Foulin, 2005). Children become familiar with several characteristics of each letter in the alphabet, including the letter's shape, name, sound and its uppercase and lowercase form. The knowledge of letter names and sounds is a strong predictor of literacy skill. In contrast, poor knowledge of letter names and sounds is associated with difficulties in the development of reading skills (Foulin, 2005).

Mechanisms used in Novel Word Reading

A notable reading researcher, Ehri (1991) has contributed to literature that has tried to understand how beginner readers are able to learn to read words. Ehri distinguished three different mechanisms that are used to read unfamiliar words (Ehri, 1991, 2005). The first mechanism is called decoding, which is when an individual sounds out graphemes into phonemes. Graphemes are defined as the written representation of phonemes, and phonemes representing distinct units of sound (Rey, Ziegler, & Jacobs, 2000). In order to achieve this step of reading development, beginning readers must learn letter-sound correspondences. The second mechanism is called analogizing (Goswami, 1986) which involves an individual using words they know, to read new words. Lastly, the third mechanism is prediction (Goodman, 1970; Chapman, 1998) where individuals use the context and letter clues to guess words that are unfamiliar. The latter mechanism is least likely to lead to productive reading (Share, 1995).

Alphabetic Knowledge

The mechanisms mentioned above demonstrate the importance of alphabetic knowledge in children's experience of learning of new words. Alphabetic knowledge was identified as one of the early skills that are indicators for identifying later reading, writing and spelling outcomes (Lonigan, Schatschneider, & Westberg, 2008). Children are able to read words just by sight through a connection-forming process between the spelling of written words to their pronunciations, and their meanings in memory (Ehri, 2005). Ehri (1991) explains that readers learn sight words by forming connections between letters in spellings and sounds in pronunciations of the words. Alphabetic knowledge is the foundation on which these connections are made.

Alphabetic Knowledge Instruction

In North America some parents provide direct instruction in letter knowledge to facilitate their children’s school readiness (Sénéchal & LeFevre, 2002). Alphabet books are instructional tools that have proven their importance in the emergence of early literacy skills (Willoughby, Evans, & Nowak, 2015). The emergence of the tablet has shifted parents’ interests from regular books, towards using iPads as a new medium for alphabet instruction (Willoughby et al., 2015). Electronic alphabet books have an advantage in that they do not use paper, and are easy to transport because multiple books can be downloaded on a single iPad. However, electronic books have also been criticized for having a multimedia design that can distract the young viewers from the important text on the screen (Willoughby et al., 2015; De Jong & Bus, 2002).

Letter Learning as a Learning Model for the Present Study

The present study used letter learning in its study design for multiple reasons. The importance of letter learning as a precursor to later literacy skills makes it necessary to examine this process in the context of the visual complexity of screens. This is particularly relevant because of the more recent use of electronic alphabet books. Letter learning begins with exposure to unfamiliar letter shapes, and testing knowledge of the letter shapes by practicing recognition skills after exposure. This early stage of letter learning was ideal for designing a study that could mimic a learning experience all individuals experience in their early years of school.

Design Features

Educational technology and media are designed to attract a child's attention, which poses a problem because they have the potential to elicit distractibility since features that are nonessential to learning may also attract attention. These learning tools often include features like speed, colour, sound and dynamic movement (Prensky, 2001). The problem lies in the fact that these very features meant to engage the children's learning, can take children's attention away from the educational content, hindering their ability to focus and learn if not relevant. For this reason, it becomes important for developers and educators to understand the mechanisms that underlie computer-based learning and the potential effect that certain design features can have on learning.

Present Study

The present study sought to determine the effect of visually busy versus visually simple screens during a task meant to encourage learning of alphabetic symbols, specifically Hebrew or Arabic letters. For the purpose of this study, the term busy is defined as having multiple pictures and animations that are irrelevant to the task. The purpose of this study is to contribute to research on the effectiveness of computer-based learning tools and the role of common design features. Computer-based learning interventions have proven to be effective with children in some contexts, although it is still unknown if the design features meant to engage children might be helping or hindering their ability to learn. It is especially important to explore this subject because most young children today have been exposed to mobile technology during infancy and throughout their childhood, periods known to be important for the development of executive functions. The child participants in the study are part of the post-mobile technology generation, as their generation is the first to have technology at their fingertips. Along with the aim to understand the role of common design features, the present study is also indirectly exploring how technology exposure during early development might affect the experience of educational materials and technology.

In this study, participants were asked to watch two videos that presented unfamiliar letter shapes (Arabic and Hebrew letters); one video was designed to be visually busy, with irrelevant animations appearing on the screen, while the second video was simpler with no animation and a minimal array of objects. In order to test for differences between the two displays, a forced-choice recognition task was used to examine any differences in information retention, and therefore learning, between the two types of presentation. By using participants who are undergraduates, grade two students and preschoolers, we aimed to determine whether there were differences in performance when presented with visually busy versus simple screens and whether there were differences across the different age groups. To take into account individual differences in technology use, participants or their parents were asked to complete a family literacy and technology use questionnaire. All participants were also evaluated on literacy and vocabulary measures. This study has three main hypotheses.

Hypothesis 1: Age effects

When examining differences in performance on the forced-choice recognition task across the three age groups, there will be a developmental difference in performance. For example, undergraduates would perform the best in both conditions. Grade two students would perform worse than undergraduates in both conditions but significantly better than preschoolers.

Hypothesis 2: Visual display effects

When examining the differences in performance between the simple and busy video conditions within each age group, there will be a greater difference between simple and busy video conditions among the grade two students. The undergraduates and the preschoolers will not demonstrate a significant difference in their performance between the two conditions, resulting in an interaction effect. Grade two students are at the age where they are still susceptible to distraction, and at the same time, have the potential to perform well in the simple video condition. In comparison, undergraduates are expected to perform at relatively similar levels on the simple and busy condition as they have developed mechanisms to filter distracting visual content and focus on what is important in their visual field. Preschoolers are expected to perform equally poorly on both tasks since at their young age they might lack the necessary attentional and memory–related skills.

Hypothesis 3: Effects of variables on performance

Vocabulary and literacy skill will be positively related to performance on the forced-choice recognition among the undergraduates and grade two students, but show no significant correlation among the preschoolers. Participants, who demonstrate strong literacy skills, may be particularly good at letter-learning as alphabetic knowledge is crucial for the development of literacy (Lonigan, Schatschneider, & Westberg, 2008). Thus, individuals, who have a higher level of literacy ability, may be relatively good at learning unfamiliar letters. Additionally, participants with good general language learning skills as measured by their English vocabulary skill might be better at learning novel letters.

Exploratory Research Question

The technology use variables from the family literacy and technology use questionnaire will help us determine whether familiarity with and frequent use of various technologies is related to performance on the forced-choice recognition task.

Methods

Participants

This study included seventy-two participants in total; twenty preschoolers (M = 2.66, SD= 0.48), twenty grade two students (M= 7.16, SD= 0.29) and 32 undergraduate students (M= 18.64, SD= 2.03). In total, 34 males (M= 9.68, SD= 6.67) and 38 females (M= 12.21, SD= 7.54) participated across the three age groups. For consistency, participants were native English speakers from the Southern Ontario region. Preschoolers were recruited from local daycares, while second graders were recruited through their schools, and undergraduate students were recruited through a local university. Eligibility for the study also required that participants do not have prior knowledge of Arabic or Hebrew as this would influence their performance on the tasks.

Measures

Family Literacy and Technology Use Questionnaire

The family literacy and technology use questionnaire was developed by Dr. Alexandra Gottardo and Dr. Eileen Wood. For preschool and grade two students, it is meant to be filled out by parents and guardians. Adults are meant to respond to the questionnaire themselves, so questions were changed to reflect the responses. The questionnaire collects information about the educational background of the parents, technology use and reading frequency, as well as the child's exposure to books and technology. The questionnaire for the parents of child participants is included in Appendix A.

Vocabulary

The Peabody Picture Vocabulary task (PPVT-III) is an individually administered standardized test of single-word receptive vocabulary (Dunn & Dunn, 1997). This measure is normed on individuals who are 2 years 6 months to 90 years and 11 months, and takes approximately 10-15 minutes to administer. It includes a version A and B. For the current study, version A was used. The test asks participants to pick which of the four presented pictures corresponds with the given word that the tester will say. After each test item, the tester notes down the response and whether it was correct or an error. Once participants have made eight errors in a set they have reached ceiling and the test is discontinued. The raw score is found by subtracting the number of errors from the ceiling item. Raw scores were then converted into standardized scores to allow us to compare individual results to the entire population.

The PPVT-III was used because it allows for the measurement of vocabulary skill, which is a good indicator of literacy ability. Participants' performance on this literacy measure was analyzed with their performance on the forced-choice recognition task after each letter learning video. The reason for assessing the participants' vocabulary skill was to identify if vocabulary knowledge was acting as a covariate and played a role in the participants' performances in the letter-learning video task. As mentioned in the literature review, alphabetic knowledge is characterized as being an early skill that predicts later literacy outcomes (Lonigan, Schatschneider, & Westberg, (2008). Thus, individuals who have a higher level of vocabulary knowledge may be relatively good at learning unfamiliar letters. Cronbach's alpha, a measure of internal consistency, is .92 for this measure.

Word Reading

The Letter-Word Identification is a standardized and highly reliable measure of English letter and word reading. This is a subtest of the Woodcock Language Proficiency Battery-Revised (WLPB-R), a group of individually administered subtests meant to measure oral language, reading and writing abilities. This measure is normed on individuals who are 2-95 years old. Grade two and undergraduate participants are asked to read letters and words aloud from a list, until the participants reach ceiling: six consecutive items incorrect in a set. Preschoolers are only required to complete the letter naming portion of this measure.

Alongside PPVT-III, WLPB-R was administered as a way to compile data on participants' literacy abilities, to study the role of literacy ability on participants' performance on the forced-choice recognition task. Cronbach's alpha for this measure is .95.

Hebrew and Arabic Letter Learning Video Tasks

The goal of the video tasks was to have participants remember two sets of ten unfamiliar letters (Arabic and Hebrew letters). This experience was meant to mimic the experience of young children who are just being introduced to the English alphabet and are being exposed to educational videos and video components of games that are meant to encourage alphabetic knowledge. Two versions of the video were created, a "simple" version and a "busy" version. Neither of the versions included audio. The videos were designed using a presentation and animation website called Powtoon. This website allows for custom video designs and video layouts, customization of animation and duration of the animations and different slides.

Simple Video

The simple video included a classroom background with a large chalkboard in the centre of the screen, a set of desks and chairs on either side, and a few other details such as a clock on the top left corner, a plant on the top right corner and a stack of books on a desk beneath the chalkboard. These objects in the classroom remained static during the letter presentation. The only dynamic aspects of the simple video were the letters that replaced each other every three seconds on the top right corner of the chalkboard. The letters take up approximately 1/6th of the chalkboard and were relatively large when considering that they were similar to the plant in the top right corner of the screen, in size. Appendix B includes a screenshot of the simple and busy videos. Upon presentation of the simple video, participants would see a classroom where every three seconds a new letter shows up on the screen, for thirty seconds in total.

Busy Video

The simple video and the busy video included the same exact classroom background, including all the same static objects present. As with the simple video, the letters appeared on the chalkboard in the top right corner, and replaced each other every three seconds. The difference between the busy and simple videos was that the busy video included animations that would appear throughout the letter presentation. These animations were not relevant to the letter portion of the task. Upon presentation of the busy video, participants would see a teacher and student slide into the classroom while the first letter simultaneously showed up on the chalkboard. Three seconds later, the second letter would appear on the screen and the student would begin to jump up and down while the teacher in the video continued to wave their hand. During the presentation of the next eight letters, different objects and animations would continue to transition in the video. Some examples of this included a bird that flew into the classroom and a student that appeared to be sleeping on a desk, snoring.

Letter Presentation

As mentioned earlier, each letter that appears in the video shows up on the chalkboard in the top right portion, and takes up around 1/6th of the chalkboard. In total, each video was 35 seconds long and presented ten unfamiliar letters for three seconds each, while five seconds included the introduction and ending of the video. The decision to present ten letters per video was made with the knowledge that working memory can hold up to seven ± two items at a time (Miller, 1956). Although working memory is not the same as recognition memory, this led us to infer that if asked to recognize each of the ten letters after being presented the video, we expected the adult participants to do relatively well. Pilot trials allowed us to determine presentation of each letter for three seconds was long enough for both the older and younger participants to potentially do well, but also to avoid ceiling effects. The pilot trials included four children between the ages 3 and 6 and five adults in total. Initially during our pilot trials participants were presented each letter for ten seconds at a time. Both adult and child participants performed surprisingly poorly using this presentation duration possibly due to memory decay. Therefore, the videos were changed to present each letter for three seconds.

Novel Letters

The unfamiliar letters used in this study were Arabic and Hebrew letters because the participants in this study were unfamiliar with these languages. Participants were asked to disqualify themselves if they had literacy exposure to these letters. In order to have enough novel letters to use in the recognition-memory task, the letter-learning videos were created using Hebrew letters for one condition and Arabic Letters for the other condition (see Appendices C & D). To ensure that the results and the effect we were seeing were because of the varying complexities of the videos and not because either of the Hebrew or Arabic was easier to remember, we developed a simple and busy version for Arabic and Hebrew. This allowed us to run half our undergraduate participants using busy Hebrew and simple Arabic, and the other half with busy Arabic and simple Hebrew. Table 1 presents the study design for the undergraduate participants. To offset any influence that the order of the videos might have, participants were counter-balanced so that the order of the simple and busy video presentation was alternated. Half of the participants viewed the simple video first and were tested using the forced-choice recognition task, then watched the busy video second and were then tested using the forced-choice recognition task while the other half saw the busy video first and simple video second. After running a t-test comparing the mean scores in the simple Hebrew (M= 8.50, SD = 1.155) and simple Arabic condition (M= 7.75, SD= 1.528), the difference in the mean scores were not significant; t (30) =-.417, p=.679). The mean scores in the busy Hebrew (M= 8.19, SD = 1.424) and busy Arabic condition (M=8.00, SD= 1.095) were also non-significant; t (30) =-.417, p=.128). Therefore, the specific alphabet being presented did not have a significant effect on the performance for either the busy or the simple conditions. This suggested that we could test the rest of the sample, preschoolers and grade two students, using the busy video made with Hebrew letters and the simple video made with Arabic letters. Since we knew that the Hebrew and Arabic letters led to the same results we did not have to control for the alphabet type and test the child participants with the other combination of videos we designed for adults, which was the simple video with Hebrew letters and the busy video with Arabic letters.

Forced-choice Recognition Task

The forced- choice recognition task was used as a way to study any learning of the letter shapes that were presented in the letter-learning video tasks. After each video, a tester presented participants with one letter that had not been presented to them earlier, and one that they had seen once. The participants were asked to pick which of the two items they remembered seeing. This was done for all ten letters that were presented in the video. During testing, the participants' responses were noted on a response sheet that was scored to determine the number of correct choices that the participant made. The pairs of items on the task are presented in Appendix E. The letters in the red boxes mark the correct items that participants were presented with in the video. The internal consistency for this measure was calculated and Cronbach's alpha is .67. This is not considered to be a strong value. A low value for Cronbach's alpha could be due to poor inter-relatedness among the different items in the task. Although a low value is not desirable in a measure, in this specific measure we do not necessarily want the different the pairs of items to be closely related to each other.

Procedure

Daycare supervisors and elementary school principals were contacted. When they had consented to taking part in the study, individual consent forms were distributed to the classrooms for the students to take home to their parents. These consent forms had the family literacy and technology use questionnaire attached so if parents were interested in the study they could send the completed questionnaire with the consent form. Undergraduate students were recruited through an online study participation system, where they could sign up to participate in ongoing research studies taking place in the university. For taking part in the study, they were offered a one credit compensation to fulfill a participation requirement for the Introduction to Psychology class. Preschoolers and grade two students were offered a five dollar donation to their school or daycare to be used at the Principal/Daycare Supervisor's discretion, as compensation. Participants' parents, who decided to have their children tested at home, were given a five dollar Tim Horton's gift card. Once participants or parents agreed to take part in the study, we arranged a convenient date and time to meet. The participants or their parents were asked to fill out the family literacy questionnaire before they or their child took part in the study. In cases where we went to schools to test children, we sent home the family literacy questionnaires along with the consent forms for the parents to complete. The questionnaires took approximately ten minutes to complete. We coordinated with classroom teachers to ensure that children were not missing important class time and by testing children during lunch or any scheduled free time they had in class. Participants were asked to watch two short videos that presented unfamiliar letters to them, one video being the simple video and the other being the busy video. Afterwards the participants were immediately tested on the forced-choice recognition task, to examine any differences in information retention, and therefore learning, between the two types of screens. The recognition memory task presented the participants with two letters at a time, and had them identify the one they remember seeing on the screen. A script of the procedure is provided in Appendix F. All participants were assessed using the PPVT-III, and the Woodcock Johnson letter-word identification measure; words and letters were used for grade two and undergraduate participants, and letters only for preschoolers. The total testing time was between forty-five minutes to an hour.

Results

The present study sought to determine the influence of visually busy versus visually simple videos on learning across three distinct age groups. It was hypothesized that undergraduates would perform best on the forced-choice recognition task in both conditions. Grade two students would perform worse than undergraduates in both conditions but significantly better than preschoolers. In addition, it was also hypothesized that differences in performance between simple and busy video conditions would be more significant in the early readers (grade two students), than among the undergraduates and the preschoolers. Vocabulary and literacy skill would be positively related to performance on the forced-choice recognition among the undergraduates and grade two students, but show no significant correlation among the preschoolers. For the purpose of clarity, performance on the forced-choice recognition task after the simple condition will be referred to as “performance in the simple condition”. Similarly, performance on the forced-choice recognition task after the busy condition will be referred to as “performance in the busy condition”.

Using a 2 (condition) by 3 (age group) mixed factorial design allowed for the comparison of performance on busy and simple conditions within and across the different age groups (undergraduates, grade two students and preschoolers). The within subjects factor was type of condition (simple or busy video) and the between subjects factor was the age group (undergraduate, grade two, or preschool). Additional analyses conducted include descriptive statistics, correlational analyses and multivariate analyses of variance.

Descriptive Statistics

All 72 participants were included in the analyses. Descriptive statistics provided a summary of the sample and their performance on the measures. Visual inspection of the mean performance of adults in the simple condition (M= 8.13, SD= 1.39) appeared higher than in the busy condition (M= 8.09, SD= 1.25). Visual inspection of the mean performance of grade 2 students in the simple condition (M= 6.60, SD= 1.47) appeared lower than in the busy condition (M= 6.80, SD= 1.36). Similarly to the grade two students, visual inspection of the mean performance of preschoolers in the simple condition (M= 4.95, SD= 1.40) appeared lower than in the busy condition (M= 5.20, SD= 1.74). Table 2 displays the means and standard deviations of performance by age group and condition.

Additionally, Table 3 presents the means and standard deviations of performance on PPVT-III (raw and standardized scores), and performance on WLPB-R (raw and standardized scores) by age group. As seen in the table, grade two students (M= 110.76, SD= 2.67). standardized means were higher than undergraduates (M= 103.94, SD= 2.10) on PPVT-III. Both grade two students (M= 118.50, SD= 3.62) and preschoolers (M= 109.35, SD= 3.61) had higher standardized means on WLPB-R than undergraduates (M= 107.28, SD= 2.85).

Correlational Analyses

A correlational analysis was conducted to allow for the examination of possible associations between performance on the four assessments in the study and age. A correlation matrix was created using age, performance on the forced-choice recognition task during the simple condition and busy condition, performance on PPVT-III (raw and standardized scores), and performance on WLPB-R (raw and standardized scores). Table 4 presents the full correlation matrix.

Simple Condition: Performance on the simple condition was highly correlated with performance on the busy condition, r (70) = .58, p< .001. Performance on the simple condition was also highly correlated with age, r (70) = .64, p< .001. Raw scores on PPVT-III, r (70) = .67, p< .001, and WLPB-R, r (70) = .69, p< .001, were highly correlated with performance on the simple condition.

Busy Condition: Performance on the busy condition was highly correlated with age, r (70) = .62, p< .001. Raw scores on PPVT-III, r (70) = .63, p< .001, and WLPB-R, r (70) = .65, p< .001, were highly correlated with performance on the simple condition.

Hypothesis 1 and 2: Performance on the forced-choice recognition task across age groups

and within each age group

One main objective of the study was to examine the differences in performance on the forced-choice recognition task across the three age groups. A 2x 3 mixed model ANOVA was used to determine the effects of condition as a within-subjects factor and the effects of group as a between-subjects factor. The between-subjects factor was group and included the performance of the undergraduates, grade two students and preschoolers. The within-subjects factor was the condition in which the novel letters were displayed, specifically the simple condition and the busy condition.

The results of the 2x3 ANOVA revealed that there was no statistically significant main effect of condition (simple or busy) on the performance in the forced-choice recognition task, $F(1,69) = 0.439$, $p=0.510$. There was a statistically significant main effect for differences in age, $F(2, 69) = 45.43$, $p<.001$. A follow-up post-hoc confirmed that there were statistically significant differences among the undergraduates and grade two students, mean difference= 1.41, $p<.001$, undergraduates and preschoolers, mean difference= 3.03, $p<.001$, and grade two students and preschoolers, mean difference= 1.63, $p<.001$. There was no significant interaction between age and condition.

In addition to the mixed model ANOVA, a multivariate analysis of covariance was conducted to examine the role of four potential covariates: order at which the simple and busy condition were administered, performance on the WLPB-R, performance on PPVT-III and lastly gender on condition. The results of the analysis revealed no significant interactions. Age group remained the only significant source of variance, $F(2, 65) =42.89$, $p<.001$.

Hypothesis 3: Relationship between literacy and vocabulary skills and performance

To determine whether there was a relationship between literacy skill and vocabulary strength on performance in the forced-choice recognition task during the simple and busy conditions, we conducted a correlational analysis using the data from each age group. For all three age groups, performance in the simple and busy conditions were unrelated to scores on PPVT-III and WLPB-R. Table 5-7 present the correlational matrixes for the undergraduates, grade twos and preschoolers respectively.

Exploratory Research Question: Technology use and performance

Descriptive statistics presented in Table 8 provide a summary of the technology use among the sample. The results of an ANOVA determined that there was a significant effect of age group on the amount of technologies used, $F\ (2, 58) = 47.11$, $p<.001$. The variable for numbers of technologies used was an aggregated score created from the variables tablet use, smartphone use, computer use, laptop use, and television use. The range for technology use scores is 0 to 1.The undergraduates (*M*=1.00, *SD*=0) used significantly more technologies than the grade two participants (*M*=.81, *SD*=.23), and the grade two participants used significantly more technologies than the preschoolers (*M*=.54, *SD*=.21).

After conducting a correlational analysis with the grade two students and preschool participants' performance during the simple and busy conditions with the questions regarding technology use from the family literacy and technology use questionnaire, only "using gaming systems for fun" had a significant but moderate correlation with performance in the busy condition, $r\ (70) = .35$, $p<.05$. Looking at the same variables a correlational analysis was conducted with the undergraduate participants. There were no significant correlations found. The list of variables used in the correlational analysis include tablet use, smartphone use, laptop use, computer use, television use, television and video frequency, computer, tablet, smartphone and gaming system use for fun, and computer, tablet, smartphone and gaming system use for educational purposes. Table 9 presents the full correlation matrix for child participants, while Table 10 presents the full correlation matrix for adult participants.

Discussion

The purpose of this study was to contribute to literature that is focused on studying video and mobile-based learning tools and how its design features play a role in the learning experience of young children. Despite the fact that computer-based and media rich learning interventions have proved to be effective, there is still more to learn about specific design features and how they may influence the experience of their younger audiences. This discussion includes an overall evaluation of the results, study limitations and suggestions for some future studies. The conclusion will include a summary of the key findings and final thoughts on the study.

Developmental Trends in Performance

In the simple and busy conditions, the participants' performance on the forced-choice recognition task demonstrated higher means for each age group. This importance of age on performance was confirmed with the results of the ANOVA that determined age as a main effect. Undergraduates performed well in the task, with grade twos performing slightly lower than them, and preschoolers lower than grade two students. Undergraduates have more experience learning unfamiliar shapes and symbols because of their mastery of the English alphabet. In addition to this, they possess more refined attentional skills, memory abilities, and perceptual abilities. It is widely agreed that visual selectivity improves with age and that one of the most significant changes that occurs with age is the improvement of perceptual abilities (Enns & Cameron, 1987). This improvement of perceptual abilities is largely because of young children's increasing ability to attend to the attributes of a stimulus that are task relevant (Enns & Cameron, 1987; Day, 1975; Gibson, 1969; Hagen & Hale, 1973; Lane & Pearson, 1982; Pick, Frankel, & Hess, 1975; Vurpillot, 1976). Additionally, the ability to sustain attention plays a critical role in learning and adaptive behavior from infancy to adulthood (Fisher, Thiessen, Godwin, Kloos, & Dickerson, 2013; Kannass & Oakes, 2008; Toro, Sinnett, & Soto-Faraco, 2005; Thiessen, Hill, & Saffran, 2005). These skills are pronounced in the older participants in this study, which explains the developmental trend in performance.

The Role of Condition on Performance

Research indicates that young learners do not have the same attentional abilities as older individuals, suggesting that busy visual displays may be a hindrance for younger children (Colombo & Cheatham, 2006; Kane & Engle, 2002; Ruff & Rothbart, 2001). However, there was not a statistically significant effect of condition (simple or busy) on the performance in the forced-choice recognition task nor was there an interaction. Our initial hypothesis was that the differences in performance between simple and busy video conditions could be more significant in grade two students, than among the undergraduates and the preschoolers. The current findings were surprising because they suggest that the grade two students' experiences with the simple and busy conditions were equal. There are two possible explanations to the grade two students' performances.

The first explanation relates back to the idea of digital natives and the fact that the participants had been exposed to mobile technology since birth. This early exposure may have played a role in influencing the nature of their cognition (Prensky, 2001). The grade two students in the study might not have the natural distractibility to visually busy screens as was initially assumed. Further, anecdotal observations during data collection suggests that the grade two students and preschoolers spent more time looking at the screen during the busy video, as compared to the simple condition. Although neither group performed differently in the two conditions, they seemed to attend to the busy video, while the simple video very quickly lost their interest. Similar to these findings, a study by Willoughby et al. (2015) found that alphabet electronic books were more successful at engaging children's attention, but this increased attention did not actually have a positive effect on their literacy knowledge performance.

Another explanation is that our specific sample of grade two students might have been exceptional for their age. The grade two students had higher standardized scores than our undergraduate sample in the vocabulary and literacy measures. Literacy ability is dependent on successful letter-learning and alphabet knowledge, suggesting that the grade two sample in this study might have been well-equipped for a letter-learning video task. Any possible differences between the simple and busy condition could have potentially been buffered by their ability to attend to and remember unfamiliar letters.

Other Variables and Performance

Our initial hypothesis was that vocabulary and literacy skill would be positively related to performance on the forced-choice recognition among the undergraduates and grade two students, but show no significant correlation among the preschoolers. The raw scores on vocabulary and word reading were related to performance on the simple condition. However, there is an effect of age on performance in the forced-choice recognition task, as well as performance on the vocabulary and reading measures. Therefore, these results do not provide us with any new insights as performance is expected to increase with age. The standardized scores, which control for age were found to not be related to either of the two conditions. These results in conjunction with those of the multivariate analysis of covariance suggest that participants' literacy abilities and vocabulary skills did not directly influence their performance in the main task.

In terms of our exploratory research question, only one technology use variable was related to performance for the child participants. The item "using gaming systems for fun" from the questionnaire data had a significant correlation with performance in the busy condition. This significant, but moderate correlation could be because children who play video games for leisure have had a lot of experience with busy visuals on screens and navigating through the different tasks in the games. This possibly helped participants' performance in the busy condition.

Limitations

The first limitation in this study was the small sample size. To be able to find conclusive results and generalize the findings of a study, having a larger number of participants is ideal. Another limitation was the fact that all the participants came from Waterloo, Ontario and its surrounding regions contributing to a lack of generalizability. Through the descriptive statistics collected from the family literacy and technology use questionnaire, the participants were in technologically saturated homes, producing a lack of variability in technology use.

Another limitation is that although we designed the videos to be distinctly different, in that one we considered simple and the other we considered busy, it is possible that despite the lack of animation the simple video itself was visually busy. The videos were designed to have the same classroom background but differed in the presence of animated objects. The simple videos still contained a substantial number of stimuli that could act as visual distractions although they were static. This could account for why there were no significant differences in the performance during the simple and busy conditions for either of the age groups.

Future Studies

The purpose of this study was to determine whether a visually busy screen presenting unfamiliar letters, negatively influences the performance of child viewers on a forced-choice recognition task. This study was motivated by two overarching ideas: (1) young children are prone to distractibility because they have not developed the same attentional mechanisms as adolescents and adults and (2) as digital natives, today's children have been exposed to visually busy screens very early in life extending its influence on their early developmental periods. A future study could make use of the interactivity of video games to see the role it plays in both busy and simple conditions. Although children do watch videos at home recreationally, and as a part of their academic curriculum, research shows that interactivity of video games has an advantage over videos because of its positive role in maintaining attention (Clark & Mayer, 2016). In addition, eye-tracking technology can be used in a study like the present study in conjunction with the other variables being measured to provide an understanding of where individual participants focus their attention and to track their visual search strategies.

Conclusion

The present study found no significant differences between performance on the simple and busy video display conditions. A possible explanation for this is that the child participants who were most vulnerable to the distractions were in fact well-equipped to cope with distractions. There was a main effect of age, which is expected given the nature of the study and its reliance on developmental cognitive skills like attention and working memory. Lastly, neither literacy skill or vocabulary skill showed a significant relationship with performance on the forced-choice recognition task. One technology use variable, "using gaming systems for fun" demonstrated a significant but moderate correlation with performance in the busy condition, among the child participants. This study sought to explore how young children today, raised in the presence of mobile technology, experience what by us may be considered as “busy” and “distracting”. Future studies should continue to explore the nature of young learners’ experiences with technology and visual screens to contribute to the understanding of how children today learn, and whether “distractions” are not necessarily distracting.

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Table 1

Study Design

	Simple	**Busy**
Arabic	Condition 1	Condition 2
Hebrew	Condition 2	Condition 1

Table 2

Means and SD by Age and Condition for Experimental Tasks

Condition	Preschool *Mean* (SD)	Grade two *Mean* (SD)	Undergraduate *Mean* (SD)
Busy	5.20 (1.74)	6.80 (1.36)	8.09 (1.25)
Simple	4.95 (1.40)	6.60 (1.47)	8.13 (1.39)

Table 3

Means and SD for Standardized Measures by Age

Measure	Preschool *Mean* (SD)	Grade two *Mean* (SD)	Undergraduate *Mean* (SD)
PPVT	38.60 (3.08)	115.79 (3.09)	173.22 (2.43)
PPVT STD	99.15 (2.65)	110.76 (2.67)	103.94 (2.10)
WLPB-R	5.55 (.87)	34.35 (.87)	52.47 (.686)
WLPB-R STD	109.35 (3.61)	118.50 (3.62)	107.28 (2.85)

Table 4

Correlations between PPVT-III, WLPB-R, Forced-choice recognition task performance and Age

	Simple	Busy	Age	PPVT	PPVT STD	WLPB-R	WLPB-R STD
Simple	-	.584**	.643**	.673**	.122	.687**	-.003
Busy	.584**	-	.621**	.629**	.041	.650**	-.008
Age	.643**	.621**	-	.911**	.017	.904**	-.186
PPVT	.673**	.629**	.911**	-	.350**	.970**	.010
PPVT STD	.122	.041	.017	.350**	-	.220	.467**
WLPB-R	.687**	.650**	.904**	.970**	.220	-	.093
WLPB-R STD	-.003	-.008	-.186	.010	.467**	0.093	-

Note: Sig ** = <.01

Table 5

Correlations between PPVT-III, WLPB-R, Forced-choice recognition task performance among undergraduates

	Simple	Busy	PPVT	PPVT STD	WLPB-R	WLPB-R STD
Simple	-	.123	-.140	-.074	.001	-.059
Busy	.123	-	.063	.078	.193	.157
PPVT	-.140	.063	-	.959**	.530**	.416*
PPVT STD	-.074	.078	.959**	-	.560	.510**
WLPB-R	.001	.193	.530**	.560**	-	.866**
WLPB-R STD	-.059	.157	.416*	.510**	.866**	-

Note: Sig ** = <.01, Sig *=<.05

Table 6

Correlations between PPVT-III, WLPB-R, Forced-choice recognition task performance among grade twos

	Simple	Busy	PPVT	PPVT STD	WLPB-R	WLPB-R STD
Simple	-	.565**	.273	.265	.005	-.004
Busy	.565**	-	.249	.181	.077	-.068
PPVT	.273	.249	-	.951**	.362	.314
PPVT STD	.265	.181	.951**	-	.251	.343
WLPB-R	.005	.077	.338	.251	-	.922**
WLPB-R STD	-.004	.020	.314	.343	.922**	-

Note: Sig ** = <.01

Table 7

Correlations between PPVT-III, WLPB-R, Forced-choice recognition task performance among preschoolers

	Simple	Busy	PPVT	PPVT STD	WLPB-R	WLPB-R STD
Simple	-	.135	.008	.072	.419	.437
Busy	.135	-	-.243	-.321	.008	-.068
PPVT	.008	-.243	-	.956**	.362	.228
PPVT STD	.072	-.321	.956**	-	.431	.384
WLPB-R	.419	.008	.362	.431	-	.902**
WLPB-R STD	.437	-.068	.228	.384	.902**	-

Note: Sig ** = <.01

Table 8

Means and SD for Technology Use Variables by Age

Variable	Preschool *Mean* (SD)	Grade two *Mean* (SD)	Undergraduate *Mean* (SD)	Range
Tech use Satisfaction	3.74 (1.24)	4.55 (.887)	3.94 (.801)	1-5
Technologies used	.539 (.206)	.814 (.228)	1.00(0)	0-1
TV and Video Viewing Frequency	2.60 (.618)	3.05 (.911)	3.03 (1.150)	1-5
Background TV	.15(.366)	.17(.383)	.46 (.999)	0-1
Tech use for Fun	1.527 (.352)	1.967 (.41)	2.194 (.792)	0-5
Tech use for Education	1.417 (.271)	1.521 (.31)	1.609 (.82)	0-5

Table 9

Correlations between Forced-choice recognition task performance and Child participants' technology use

	Simple	Busy	TV and Video Frequency	Computer use for fun	Tablet use for fun	Smartphone use for fun	Gaming system use for fun
Simple	-	.485**	-.064	.113	-.060	.127	.259
Busy	.485**	-	.122	-.016	.122	.041	.348*
TV and Video frequency	-.064	.122	-	.309	.133	.057	.272
Computer use for fun	.113	-.016	.309	-	.300	.280	.245
Tablet use for fun	-.060	.122	.133	.300	-	.337*	.564**
Smartphone use for fun	.127	.041	.057	.280	.337*	-	.357*
Gaming system use for fun	.259	.348*	.272	.245	.564**	.357*	-
Computer use for education	.217	-.032	.181	.806**	.433*	.318	.462**
Tablet use for education	.028	-.042	-.220	-.038	.659**	.124	.461**
Smartphone use for education	-.207	-.206	-.091	-.086	.079	.370*	.135
Gaming system use for education	.269	.115	.151	.257	.271	.143	.707**

Note: Sig ** = <.01, Sig *=<.05

Table 9 Continued

Correlations between Forced-choice recognition task performance and Child participants' technology use

	Computer use for education	Tablet use for education	Smartphone use for education	Gaming system use for education
Simple	.217	.028	-.207	.269
Busy	-.032	-.042	.206	.115
TV and Video frequency	.181	-.220	-.091	.151
Computer use for fun	.806**	-.038	-.086	.257
Tablet use for fun	.433*	.659**	.079	.271
Smartphone use for fun	.318	.124	.370*	.143
Gaming system use for fun	.462**	.461**	.135	.707**
Computer use for education	-	.266	-.053	.441*
Tablet use for education	.266	-	.181	.348
Smartphone use for education	-.053	.181	-	.267
Gaming system use for education	.441	.348	.267	-

Note: Sig ** = <.01, Sig *=<.05

Table 10

Correlations between Forced-choice recognition task performance and Adult participants' technology use

	Simple	Busy	TV and Video Frequency	Computer use for fun	Tablet use for fun	Smartphone use for fun	Gaming system use for fun
Simple	-	.123	.099	.180	-.093	.306	-.322
Busy	.123	-	-.092	.001	.173	.078	-.125
TV and Video frequency	.099	-.092	-	.292	-.255	.322	-.014
Computer use for fun	.180	.001	.292	-	-.345	.744**	-.009
Tablet use for fun	-.093	.173	-.255	-.345	-	-.285	.340
Smartphone use for fun	.306	.078	.322	.774**	-.285	-	-.300
Gaming system use for fun	-.322	-.125	-.014	-.009	.340	-.300	-
Computer use for education	.163	-.041	-.031	.501**	-.204	.481**	-.263
Tablet use for education	.169	.129	-.271	.188	.173	.273	-.152
Smartphone use for education	.154	.173	.021	.402*	-.156	.424*	-.263
Gaming system use for education	-0.24	-.020	-.007	-.255	.679**	-.319	.552**

Note: Sig ** = <.01, Sig*= <.05

Table 10 Continued

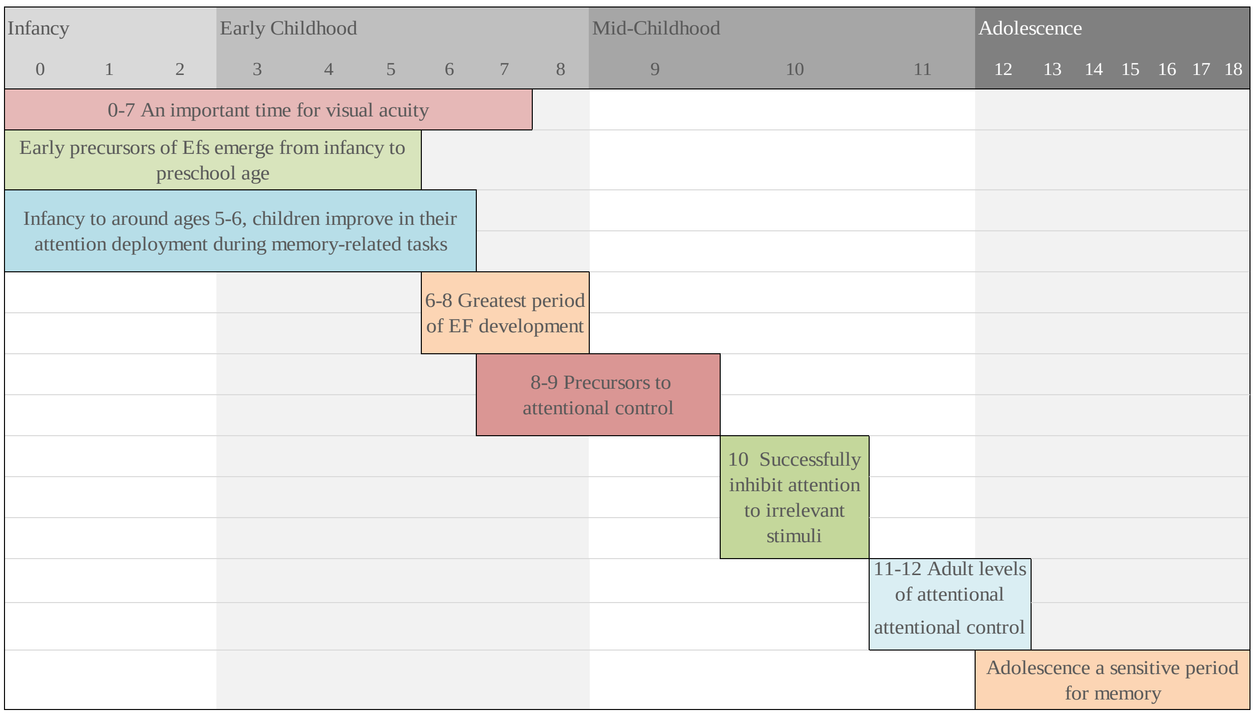
Correlations between Forced-choice recognition task performance and Adult participants' technology use

	Computer use for education	Tablet use for education	Smartphone use for education	Gaming system use for education
Simple	.163	.169	.154	-.024
Busy	-.041	.129	.173	-.020
TV and Video frequency	-.031	-.271	.021	-.007
Computer use for fun	.501**	.188	.402*	-.255
Tablet use for fun	-.204	.173	-.156	.679**
Smartphone use for fun	.481**	.273	.424*	-.319
Gaming system use for fun	-.263	-.152	-.263	.552**
Computer use for education	-	.525**	.531**	-.290
Tablet use for education	.525**	-	.530**	.175
Smartphone use for education	.531**	.530**	-	.317
Gaming system use for education	-.290	.175	.317	-

Note: Sig ** = <.01, Sig*= <.05

Figure 1

Timeline of Developmental Events



*Efs= Executive functions

Appendix A

Family Literacy and Technology use Questionnaire

In order to be able to better understand the factors that influence a child's ability to learn from educational software, we would like to obtain some information about language knowledge and technology use in the home. We would greatly appreciate it if you would complete the following questions concerning your family and your child who is in the study.

Today's date: _________________

Please answer these questions about the child in the study.

1. Child's date of birth:
   Child's current grade _____________________________

2. Has your child ever received extra help for problems in the following areas:

	Reading	Printing	Writing	Speaking
Please check all relevant				

3. What language or languages are spoken at home?

Main language: _______________________
Other(s): __________________________

4. Does your child use any of the following electronic devices in your home/ vehicle/ on outings?

Tablets/ iPads Y/N Smartphones Y/N Laptops Y/N Computers Y/N TVs Y/N

Which of these does your child use at daycare/ school/Other person's house

5. a) How often does your child watch TV or videos?

	More than 3 hours per day	2-3 hours per day	1 to almost 2 hours per day	Less than 1 hour per day	Never
Pick one					

b) The TV is always or almost always on in the background. Y/N

6. How often does your child play with or watch videos and games **just for fun**?

Device	More than 3 hours per day	2-3 hours per day	1 to almost 2 hours per day	Less than 1 hour per day	Never
Gaming system					
Computer					
Tablet					
Smart phone					

7.How often does your child play with or watch **educational** videos and games?

Device	More than 3 hours per day	2-3 hours per day	1 to almost 2 hours per day	Less than 1 hour per day	Never
Gaming system					
Computer					
Tablet/ iPad					

When my child uses technology they use it:

Almost always on their own	Most of the time on their own	Half of the time on their own, half the time with an adult present	Most of the time with an adult present	Almost always with an adult present

How much does your child enjoy using technology?

A lot	Quite a bit	Somewhat	A little	Not at all

8. How often does your child read at home?

	More than 2 hours per day	1-2 hours per day	Less than 1 hour per day but more than 15 minutes	Less than 15 minutes per day	Almost Never
Pick one					

How much does your child enjoy reading?

A lot	Quite a bit	Somewhat	A little	Not at all

9. How often do **you** read at home to your child?

	More than 2 hours per day	1-2 hours per day	Less than 1 hour per day but more than 30 minutes	Less than 30 minutes per day	Almost Never
Pick one					

10. Approximately how many books do you have at your house that your child has read or might read (including library books)?

	1-2	3-5	5-10	10-25	25-100	100+
Pick one						

Please answer these questions about yourself.
Circle who is completing this questionnaire: Mother Father
Other (specify): _______________

How old are you?

20-29	30-39	40-49	50-59	60+

11. What is your native language(s)? _______________
What is your native country? ________________
If you were not born in Canada, at what age did you move to Canada? _________

12. For each of the following **English** language skills, please rate how well you feel that you can currently perform the skill. (circle one number per skill)

			ability none									very fluent
Understanding			1	2	3	4	5	6	7	8	9	10
Speaking			1	2	3	4	5	6	7	8	9	10
Reading			1	2	3	4	5	6	7	8	9	10
Writing			1	2	3	4	5	6	7	8	9	10

13. Please place an X beside the highest level of education that you have attained.
_____ Elementary school
_____ Some high school studies
_____ Completed high school
_____ Some college or university studies
_____ Completed college diploma
_____ Completed undergraduate degree
_____ Some postgraduate studies
_____ Completed graduate or professional degree

14. What is your occupation? : ____________________________________
If you are a new Canadian and were employed before immigrating to Canada, please indicate your occupation in your former country ___________________

7. How many electronic devices do you use daily?

Tablets ___________ Smart phones ______Laptops ___________TVs ________

Other (Please specify): ________________

8. How often do you watch TV or videos?

	More than 3 hours per day	2-3 hours per day	1 to almost 2 hours per day	Less than 1 hour per day	Never
Pick one					

9. How often do you play digital games?

	More than 3 hours per day	2-3 hours per day	1 to almost 2 hours per day	Less than 1 hour per day	Never
For pleasure					

10. How often do you read?

	More than 2 hours per day	1-2 hours per day	2-5 hours per week	Less than 2 hours per week	Never
For work					
For pleasure					

Please answer these questions about the other parent/ guardian, if your child lives with or has regular contact with that person.

The other person is the: Mother Father Other: _______________
How old is the other person?

20-29	30-39	40-49	50-59	60+

15. What is your native language(s)? ______________
What is your native country? _______________
If you were not born in Canada, at what age did you move to Canada? ________

16. For each of the following **English** language skills, please rate how well you feel that you can currently perform the skill. (circle one number per skill)

			Ability									
			none									very fluent
Understanding			1	2	3	4	5	6	7	8	9	10
Speaking			1	2	3	4	5	6	7	8	9	10
Reading			1	2	3	4	5	6	7	8	9	10
Writing			1	2	3	4	5	6	7	8	9	10

17. Please place an X beside the highest level of education that you have attained.
_____ Elementary school
_____ Some high school studies
_____ Completed high school
_____ Some college or university studies
_____ Completed college diploma
_____ Completed undergraduate degree
_____ Some postgraduate studies
_____ Completed graduate or professional degree

18. What is your occupation? : _____________________________________
If you are a new Canadian and were employed before immigrating to Canada, please indicate your occupation in your former country __________________

Thank you for completing the Family Language Questionnaire. We look forward to sharing the findings of the project with you.

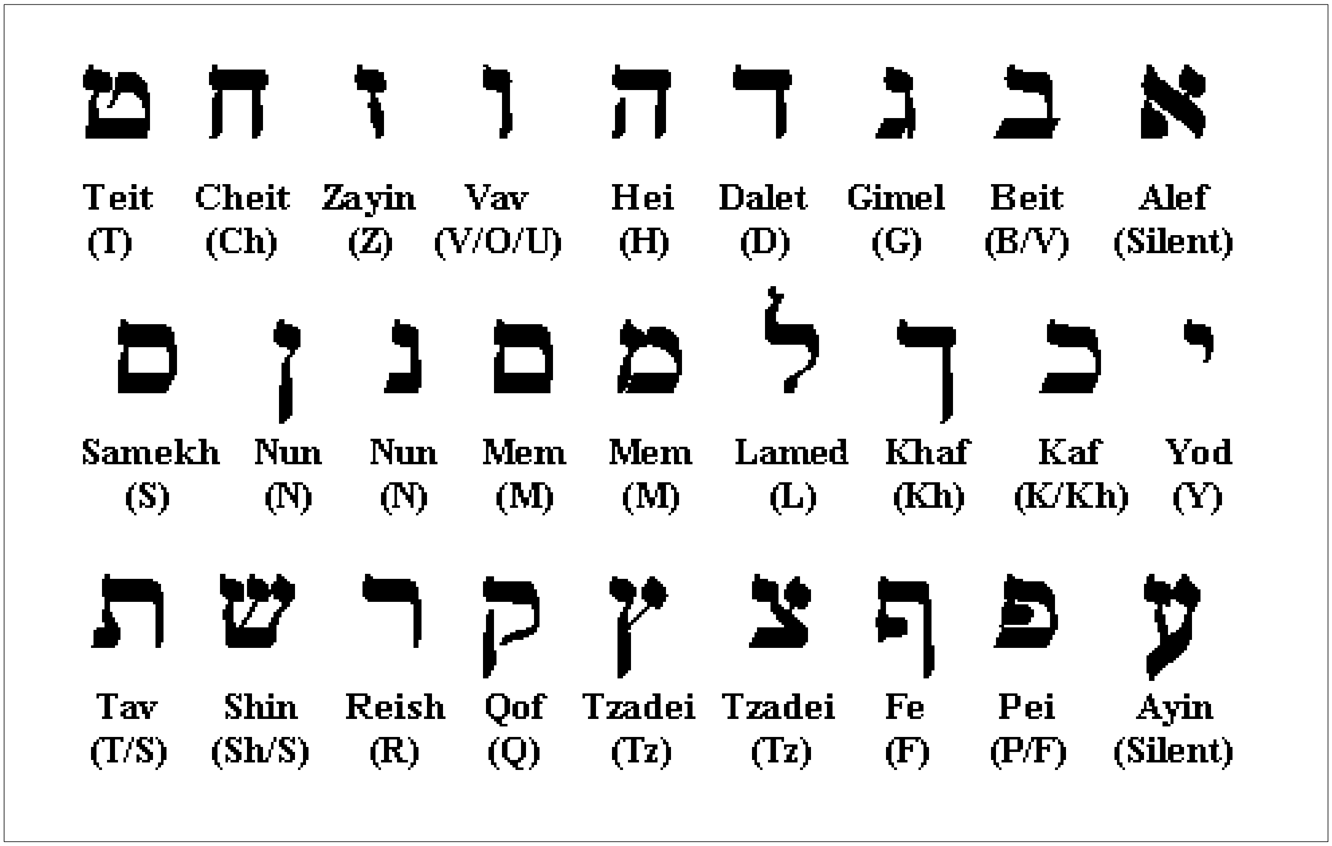
Appendix B

Busy Video

Simple Video

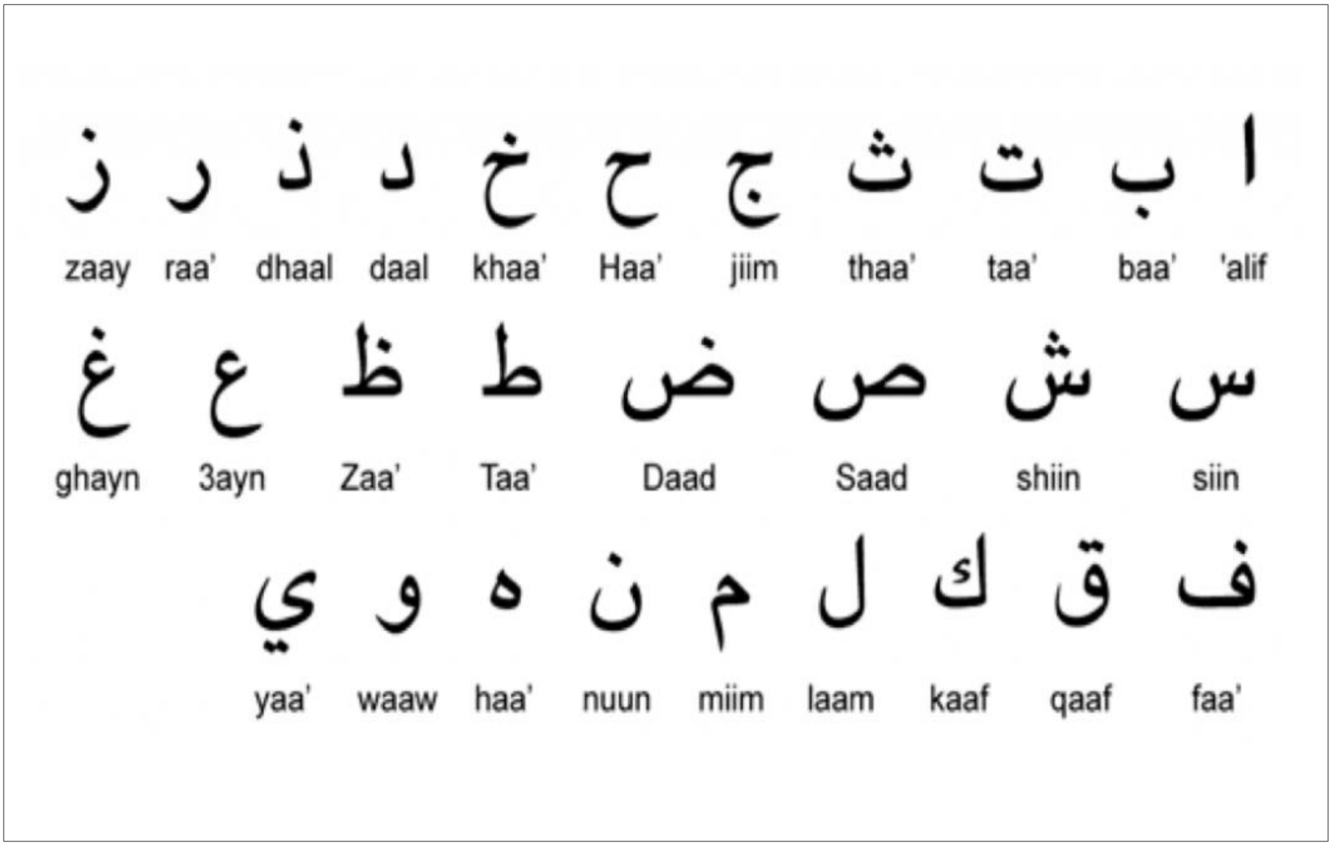
Appendix C

Hebrew Alphabet



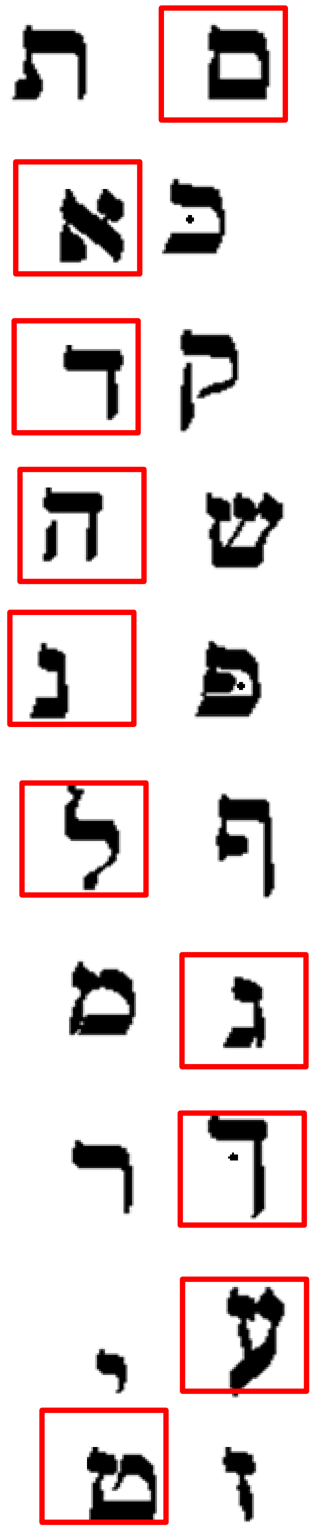
Appendix D

Arabic Alphabet



Appendix E

Forced- Choice Recognition Task -Hebrew



Forced-Choice Recognition Task- Arabic

ج	و
ز	ش
ط	ق
س	ظ
ا	ن
ه	ي
غ	ت
ح	ك
ع	ل
ف	م

Appendix F

Script

Researcher: I am going to play a short video for you that will present shapes that you have not seen before, and I want you to try and pay attention to them because we are going to see if you remember them afterwards.

*Researcher plays video. Once the video is over, the researcher will assess the participant using the **recognition memory task**.*

Researcher: Okay, now I am going to present you with two shapes, one of them was in the video you just saw, and one was not. Can you point to the one you remember seeing in the video?

Researcher will take note of response, and continue this process for a total of ten times. Once the recognition memory task is over for the first video, the researcher will play the second video.

Researcher: Now, I am going to play another short video for you that will present more shapes that you have not seen before, and I want you to try and pay attention to them because we are going to see if you remember them afterwards.

*Once the second video is over, the researcher will assess the participant using the **recognition memory task**, and using the same instructions as the previous video.*