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Abstract

The American Academy of Pediatrics (AAP, 1999) recommends that parents limit their 2- to 5-year-old children to 2 hours of television per day. This recommendation is due in part to research showing that a video deficit effect exists in which children under the age of 2 learn significantly worse from a video than from a live person. Fifty 30- to 36-month olds completed a word-learning task, trained either in person or through a video, while their parent took a survey regarding their screen media viewing habits. There was a significant interaction between condition and screen media hours watched. Children who watched below the AAP's recommended 2 hours per day retained a video deficit while those who watched 2 or more hours per day learned equally well from both conditions. This suggests that the video deficit is overcome following greater exposure to screen media. Further investigation revealed that regardless of condition, children who watched between 45 and 75 minutes of screen media per day outperformed their peers, suggesting that there may be an optimal amount of screen media exposure necessary for kids to learn from both sources.

Screen Media and Children's Word Learning

In 2008, The Neilson Company shocked society when they determined that children between the ages of 2 and 5 spend an average 32 hours a week with their eyes on a screen (McDonough, 2009). This is the case even though the American Academy of Pediatrics (AAP, 1999) has recommended that parents discourage their children under the age of 2 from watching television at all, and limit those older than 2 to 2 hours per day. In reality, a study done by Rideout and Hamel in 2006 found that a mere 24% of children this age actually follow that AAP guideline. Over the years, more and more television shows and videos have been released that claim they can help children learn new information. Popular shows such as *Sesame Street* and *Dora the Explorer* focus heavily on vocabulary learning, but the question remains as to how well children can actually learn new words from a screen.

The purpose of the present study is to explore how young children learn new words from screen media, such as television and videos, compared to how well they learn from a live model, and how their learning from these two sources is related to their amount of exposure to screen media. Before turning to the limited experimental evidence on this question and the design of the present study, I provide an overview of studies on the amount of screen media viewed by young children and how individual differences in screen media viewing are correlated with children's cognitive abilities.

Although marketing efforts have been increasingly focusing on children, it is important to identify how much screen media young children are actually using. Zimmerman, Christakis, and Meltzoff (2007) set out to determine the television viewing habits of children younger than 2. They randomly surveyed 1009 parents of children aged 2-24 months in Minnesota and Washington state. They found that by 3 months of age, 40% of children were regularly watching

TV and 90% regularly watched by the age of 24 months. Children younger than 1 year watched an average of 1 hour per day compared to 1.5 hours by the age of 2. Rideout and Hamel (2006) found the average to be one hour per day of television viewing compared to only 40 minutes per day spent reading or being read to for all kids aged 0-3. They also surveyed parents about their percieved effects of various sources of screen media. They found that 69% of parents believed computers mostly helped children's learning, but only 17% believed that video games mostly helped children's learning. Regarding television, parents' views were pretty split, as 38% believed that television mostly helped and 31% believed it mostly hurt children's learning. The rest were undecided or claimed it had little effect. Because parents are so split on this issue, researchers have tried to answer this question for them.

First, researchers investigated the educational claims made by screen media aimed at young age groups. Fenstermacher et al. (2010) evaluated claims listed on packaging, websites, and promotional materials for 686 infant DVDs. They focused on claims regarding the target audience's age range, viewing recommendation (e.g. viewing-only, viewing with participation, viewing with another person), research referenced, and implicit versus explicit claims. Implicit claims used non-specific words to talk about learning goals (e.g. explore, introduce). Explicit claims used specific verbs like "teach" to identify the learning of a particular skill. Overall, most of the claims made were implicit, general-knowledge claims. Claims about language development were equally weighted between implicit and explicit. Infant DVDs that made claims most often did so about general knowledge building and language learning rather than social-emotional claims. This may be in response to parents' concerns about preparing children for school through academic growth. Furthermore, the number of claims made about a certain domain of learning was directly correlated with percentage of scenes featuring the domain content. Lastly, DVDs that reference research are correlated with greater perceived benefit by parents. Given all these claims, the question remains as to how much these videos can actually help a child's learning. First, however, it is necessary to establish whether any benefits of these videos come with a trade-off; specifically, can these videos have any negative effects on a child's development?

Various conflicting sources address the effects of television watching on children's future development. The first argument is that television may alter the course of normal brain development. Christakis (2009) emphasizes that since the brain triples in size during the early years of life and "this growth occurs in direct response to external stimulation," parents should be especially wary of their children's exposure to screen media (p. 10). According to Courage and Setliff (2009), researchers have documented the importance of the first 3 years of life on brain development due to a "sensitive period for neural plasticity" (p. 73). For this reason, many researchers as well as the AAP have recommended limiting young children's exposure to screen media to avoid any developmental damage that it could cause (Courage & Setliff, 2009). On the other hand, Charles Nelson (1999) claims that since this sensitive period mostly refers to sensory development, it is unlikely that a child's exposure to screen media will prevent that normal development: "A particular experience needs to occur within a somewhat broad period of time in order for development to proceed normally" (p. 236). Although there is general agreement about the various sensitive periods in brain growth, Bruer and Greenough (2001) say that these periods are most necessary for one of two kinds of development. Experience-expectant development requires a specific experience to occur in order to continue normal brain development. Experience-dependent development refers to additional development that is not necessary but can still generate new synapses and is different for every individual. Experience-expectant development requires regular experience that children will find in the world regardless of their exposure to screen media. From this perspective, television-viewing will only really affect the experience-dependent development, for example, their additional word learning, but should not impair their experience-expectant development such as the ability to learn language in the first place.

Other researchers have made claims based on their research regarding the negative impact screen media has on children's experience-dependent cognitive development. A longitudinal study conducted by Schmidt and colleagues in 2009 addressed the question of what effects television viewing under the age of 2 has on children's cognitive development. They studied 872 children for 3 years, collecting information on their TV viewing, lifestyle habits, and demographic measures, and assessed their cognitive abilites using a variety of measures when the children were 3 years old. Children's amount of TV watching was correlated with lower language and visual motor skills. This association was not significant after the authors adjusted for multiple family and individual characteristics like maternal income, education, ethnicity, and average sleep duration. Overall, they concluded that there was no independent association between television viewing at a young age and later cognitive abilities.

The study done by Zimmerman, Christakis, and Meltzoff (2007) involved conducting phone interviews with 1008 parents with children between the ages of 2-24 months. They asked questions about the child's TV-viewing habits and had the parents complete a shortened version of the MacArthur-Bates Communicative Development Inventory (MCDI; Fenson et al., 1992) which provides a standardized measure of a child's vocabulary. The researchers found that each additional reported hour of television watched correlated with about a 17 point decrease (out of 90) on the MCDI measure for very young children aged 8-16 months after controlling for parental interaction and demographic information. This corresponds to a difference of about 6 to 8 words. However, the nature of this correlational data prohibits drawing a causal conclusion. It's possible that when parents are concerned about their child's delayed language development, they turn to videos for help (Zimmerman, Christakis, & Meltzoff, 2007). Furthermore, this correlation did not exist in the older sample of 17- to 24-month-olds.

Studies done with slightly older children revealed other correlations between TV viewing and lower scores on cognitive measures. A different study done by Zimmerman and Christakis (2005) set out to test the relationship between TV viewing and cognitive development using a longitudinal correlational design, but in a slightly older age group. The researchers collected data from children before age 3 and again between ages 3 and 5. Children in this sample watched an average of 2.2 hours per day before age 3 and 3.3 hours between ages 3 and 5. Each hour of TV watching (before age 3) was seen to be correlated with a 0.58 points decrease on the Peabody Individual Achievement Test (PIAT) Reading Recognition Scale. The scale has a normed mean of 100 and a standard deviation of 15 points. However, once the child turned 3, for each hour of TV viewed, children improved 0.51 points. It is important to note that although the PIAT assessed mathematics, reading recognition, and reading comprehension, the correlation was only found with the reading recognition portion. The researchers also found a decrease of 0.10 points on the Memory for Digit Span assessment from the Wechsler Intelligence Scales for children per each hour of TV watched. The Digit Span task assessed short term memory by asking children to repeat back a list of numbers either forwards or backwards; it was based on a mean of 10 and standard deviation of 3. Again, this study is merely correlational, so we cannot identify a cause. However, as it would be unrealistic to randomly assign children to high and low TV watching conditions for the duration of their childhood, this will remain a limitation to any study of this kind. However, the researchers in this study concluded that the AAP guideline that children under age 2 watch no television is warrented based on the results they found (Zimmerman & Christakis, 2005).

Previous research has identified many possible negative consequences of early screen media exposure; however, some researchers have found positive effects as well. Linebarger and Walker (2005) found that for older children (30 months old and up), certain television shows (e.g. *Blue's Clues* and *Arthur*) were actually positively correlated with larger vocabularies and higher language scores. Others have documented higher scores on the Bracken School Readiness Scale (that measures a child's knowledge of colors, letters, numbers, and shapes) among children who watched educational shows such as *Sesame Street* in preschool (Wright et al., 2001). In 2004, Christakis found that attentional problems were correlated with amount of time spent watching TV, but this correlation did not exist when the content of the shows was educational. Perhaps it is not the screen itself that is harmful but what kinds of information and images children are exposed to when viewing screen media that are associated with harmful outcomes.

Anderson and Hanson (2009) maintain that parents should stop worrying about the amount of television kids are viewing and more importantly focus on what they are viewing. They claim that the worry of how much time kids are spending watching television is due to the trade off: the idea that they will spend less time participating in other activities that could be more helpful to their development. They determined that time spent watching screen media is likely not the primary cause for the correlations found relating screen media to cognitive problems later in life. Other factors may be the underlying cause for children's low scores on cognitive measures. For example, busy parents who are already inclined not to socialize much with their child may be more inclined to let the child watch a lot of television. It could, in fact, be the lack of socialization that causes the child to perform relatively poorly on certain tasks. Furthermore, they recognize that if the content of television watched "is overwhelmingly violent or otherwise negative," then it probably does not have any positive effects on the child (Anderson & Hanson, 2009, p. 1205). Educational shows, on the other hand, might have positive effects. Even Christakis (2009) and the AAP (1999) recognize that the potential positive effects of screen media aimed at aiding children's learning are still up for debate.

Correlational studies offer an incomplete picture of the effects screen media exposure has on children's learning. In fact, none of the studies cited so far experimentally tested the nature of children's learning from a screen. Those that have, found that young children learn significantly better from a live person than from a screen, a pattern now commonly referred to as the video deficit effect (Anderson & Pempek, 2005). Nevertheless, a video deficit does not mean children cannot learn at all from a video. In fact, infants have been proven capable of imitating actions viewed on a screen. For example, in one study 12-, 15-, and 18-month-old children watched an adult perform a short three-step procedure on a toy either in person or on a screen (Barr & Hayne, 1999). Across all age groups, children could imitate the actions, but did a better job after seeing a live demonstration rather than a video demonstration. This deficit appeared again in a word-learning study by Krcmar (2007) in which 15- to 24-month-olds learned novel names for unfamiliar objects better from a live person than from a video. However, the impact of the video deficit effect is still unclear for kids older than 2 years, and the question remains as to what role habitual screen media viewing plays in their ability to learn new words from that media.

Current Study

In this research, I investigate how time spent watching screen media is related to a child's language development. Specifically, I want to know how well children are able to learn new words from a screen versus a live person and how that is affected by their daily exposure to screen media sources. Additionally, I want to get a measure of each child's vocabulary level in order to test for the correlation Zimmerman, Christakis, and Meltzoff (2007) found between vocabulary and screen media viewing time. I can also use this measure as a control when running other analyses.

Many studies have suggested that too much television is bad for children's cognitive development. However, certain research has suggested that screen media might only alter experience-dependent development (Bruer & Greenough, 2001). In terms of language development, this means that the amount of television viewed by a child should not affect necessarily have a negative influence on their ability to learn new words from screen media. I hypothesized that the video deficit may actually disappear as a result of children establishing familiarity with screen media. That is, by the age of 2, children overall may have been exposed to enough screen media to have learned how to learn from it. Therefore, I also predict that hours of television viewed is not directly correlated with a child's performance on a word learning task. Furthermore, since the video deficit has only been consistently shown in children under the age of 2, I expect that it will not exist in my sample of 2.5- to 3-year-olds. That is, I predict that children will be able to learn new words from a screen just as well as they can in person. Furthermore, since the correlation found by Zimmerman, Christakis, & Meltzoff (2007) for 8- to 16-month olds was not found for older slightly older children, I predict there will no correlation between vocabulary level and screen media viewing time in my sample of older children.

Methods

Participants

This study included 50 children, 23 were female. The participants' ages ranged from 30 to 36 months (*M* = 33.23, *SD* = 1.75). Participants were recruited through a database of families from the Boulder County area in Colorado. Families were contacted by phone or e-mail and came to Dr. Colunga's lab on campus to participate in the study. Each child's parent gave consent for participation on behalf of the child and agreed to take the survey regarding their child's screen media viewing habits. At the end of each visit, parents were compensated $5 and each child received a book as a prize for participating in the project.

Research Design

Multiple analyses were conducted to investigate the question of how screen media usage affects children's word learning. Various independent variables were used to explore the child's performance on the word-learning task (the dependent variable). The first analysis completed (analyis A) was used to find out if our sample of children older than 2 learned less from a video than from a live person, i.e., retained the video deficit effect which has been documented in younger children (see Introduction). Therefore, the independent variable in experiment A was training condition (in-person or video). This experiment was a one-factor between-subjects true experiment in which participants were randomly assigned to conditions, and the analysis was conducted using an independent samples t-test.

The second analysis (analysis B) investigated whether a correlation existed between time spent watching television and video (the independent variable) and task performance (dependent variable). Experiment B was a passive observational design and analyses were conducted with Pearson's correlation tests.

A third analysis (analysis C) tested the correlation between time spent watching television and video (independent variable) and vocabulary score (dependent variable). Both of these measures were results of parent-reports, therefore experiment C was also a passive observational design and analyses were conducted with correlations.

An additional analysis (analysis D) was conducted to further investigate the interaction between training condition and screen media hours (with respect to the AAP's 2-hour per day recommended limit) on word-learning task performance. The data was analyzed using a 2x2 ANOVA design. The independent variables were training condition (in person or video) and screen media viewing hours per day (more or less than the AAP's recommended 2 hour limit). Post-hoc t-tests were also performed between groups to determine where the main differences were.

Lastly, a final analysis (analysis E) was used to determine how important the AAP's screen media limitation was to a child's ability to learn new words. The children were divided into three groups based on their individual time spent watching screen media. The 33% of children with the lowest reported screen media viewing time became the "lower" group, the 33% of children with the highest reported screen media viewing time became the "upper" group, and the 33% of children left in the middle became the "middle" group. These groups of thirds acted as one of the independent variables; the other independent variable was condition. The data was then analyzed using a 2x3 ANOVA design. Again, post-hoc t-tests were also performed between groups to determine where the main differences were.

Materials

Stimuli. The stimuli consisted of a set of 6 novel solid objects that were all made in the lab as a part of a larger study that were labeled with novel names (e.g. "Elg" and "Nork").

Images of these objects can be found in Figure 2. A video was created for the video training condition that showed the experimenter introducing each object, naming it aloud, and rotating it. The video was filmed from the point of view of a child sitting in a chair across the table. The video was taken in the same setting as the actual experiment took place and was presented through a laptop on the table in front of the child. Datasheets consisted of pictures of six pairs of the novel objects to be presented to the child in the testing phase on which the researcher marked which object the child chose when the object name was spoken by the experimenter. It is important to note that the testing phase was always done with a live experimenter regardless of the condition in which the child learned the object labels.

Screen Media Survey. The survey completed by each parent required that the parent estimate the amount of time their child spent on various activities per day. These activities included "Watching television," "Watching a video," "Playing outside," "Reading or being read to," etc. The parent was instructed to check the box indicating the amount of time their child spent on the activity in a typical day (see Figure 1). The survey was completed during the second visit.

MCDI-III Vocabulary Checklist. The MacArthur-Bates Communicative-Development Inventories (MCDI) is an extensive vocabulary checklist designed for toddlers ages 17-30 months. The MCDI-III is an extension to the original MCDI designed for children over the age of 30 months. At this age, children have such a broad vocabulary, it would be unfeasible to idenfity a list of words that is comprehensible (Fenson, et al., 2007). The MCDI-III involves three parts, one of which is the vocabulary checklist. This is the only part used in this experiment. The MCDI-III vocabulary checklist includes 100 words of varying difficulty such that ceiling effects are overall avoided. Parents check off the words that their child can produce for a final score that ranges from 0-100. The MCDI-III has been shown to be a valid way to measure language development variability among individual children (Zimmerman, Steiner, & Pond 1992; Mercure, 1999; Feldman et al., 2005). In addition, it is easy to administer. Parents were instructed to mark the words they have heard their child produce (differentiating between *production* and *knowledge*). We told parents that if their child systematically uses a different pronunciation of a word (for example, "sketti" for "spaghetti"), to mark the word anyway. If the child is knows multiple languages, we told parents to mark the words their child produces in all languages.

Procedure

The experimenter in this study was one of four female researchers; three were undergraduates and one was a doctoral candidate. The entire project required each child participant to complete two visits with 1-2 weeks between them and was conducted in a lab in the Muenzinger Psychology Building on the CU-Boulder campus. On the first visit, the parent signed the consent form for their child's participation and for their own agreement to complete a survey, and the child was randomly assigned to either the in-person or the video training condition. Each condition consisted of 12 females and 13 males.

Training. After the form was completed, the child, parent, and experimenter moved to another room in the laboratory to complete the experimental tasks. The parent was welcome to join the child on one side of a table while the experimenter sat on the opposite side. The experimenter then told the child, "We're going to play a game now!," and proceeded with either the in-person or video training condition. In the in-person condition, the experimenter began the training by presenting each object in a specified order; there were 2 counterbalanced orders to control for order effects; one of these orders was randomly assigned to each participant. The objects were kept behind a shelf so that the child only saw the object(s) presented to them by the experimenter. Each time the experimenter presented an object, she said the following, "This is a ____. Do you see the ____? This is my ____," pausing as necessary when the child seemed interested. She then repeated the order so that the child saw each object twice. This procedure was replicated in the video that was shown to the children in the video condition. The live experimenter simply started the video from a laptop sitting in front of the child and took the laptop away when the video ended without stopping or pausing the video at any time.

Testing. The testing session immediately followed the training session and was repeated at the second visit. The test was a forced-choice format in which the experimenter presented the child with two objects and asked the child to identify, either by pointing or handing the object to the experimenter, "Which one of these is the ____?" The experimenter then recorded the child's response on the datasheet and took both objects away before beginning the next testing trial. There were a total of six forced-choice testing trials each visit such that each object was asked for once per visit. This testing procedure was the same for all children regardless of which training condition they experienced.

On the second visit, the experimenter gave the parent the survey to complete while the child was playing the "game." The parent and child again sat on the same side of the table while the experimenter sat opposite them. This time the child only completed the testing phase but not the training phase. Another six forced-choice trials were given and recorded. These trials were added to the previous week's 6 trials for a total of 12 trials and a maximum total correct score of 12. After the experiment was completed, the survey was retrieved from the parent. At the end of each visit, parents were given $5 and children were given a book as a prize for playing the game.

While walking the parent and child out of the lab, the researcher debriefed and thanked the parent, explaining the expected results of the experiment.

Results

It should be noted that this study differentiates between noninteractive screen media (e.g. television, video) and interactive screen media (e.g. computer/tablet use). We were able to categorize the types of screen media used due to the nature of the survey and made this distinction to see whether one type of screen media had a greater effect than the other. All statistical tests were done with both noninteractive screen media and all types of screen media (i.e. interactive and noninteractive), but the results never changed significantly because of this. The two were strongly and positively correlated, $r = 0.916$, $p < 0.01$.

Analysis A examined whether the video deficit effect existed in the sample by comparing percent correct answers based on training condition. There was a significant difference in total correct answers between participants in the in-person versus video training conditions, $t(48) = 2.78$, $p < 0.01$. Overall, children did learn better from a live person ($M = 66\%$, $SD = 14\%$ than from a video ($M = 56\%$, $SD = 10\%$).

Analysis B observed how participants' screen media watching habits related to their performance on the word-learning task. There was no significant correlation between hours of screen media viewed per day and total correct responses on the task, $r = -0.050$, $p = 0.730$. The correlation was still not significant when other forms of screen media such as computer and video game hours were included, $r = 0.026$, $p = 0.859$. The correlation was also not significant when controlled for total time per day accounted for by any of the activities listed on the survey, $r = -0.028$, $p = 0.849$. In fact, there was also no significant correlation between time spent reading or being read to and total correct reponses on the task, $r = -0.052$, $p = 0.720$.

Analysis C looked at the relationship between time spent watching TV and video and a child's vocabulary score. There was a significant negative correlation between these variables, $r = -0.522$, $p < 0.001$. Children who watch more television tend to have lower vocabulary scores (see Figure 3). However, there was not a significant correlation between time spent reading or being read to and a child's vocabulary score, $r = 0.108$, $p = 0.462$. Because of the significant negative correlation between TV-viewing and vocabulary score, we considered whether a child's vocabulary score was actually more related to performance on the word-learning task than TV-viewing hours. However, this was found not to be the case, as there was no significant correlation between vocabulary score and total correct responses, $r = 0.178$, $p = 0.220$.

Analysis D was performed to investigate the impact the AAP's screen media limitation guideline has on children's word-learning. The between-subjects factors were condition (in-person or video) and screen media hours per day (less than 2 hours per day or 2+ hours per day). This data was analyzed using a 2x2 factorial ANOVA. There was no significant main effect of training condition, $F(1, 46) = 1.338$, $p = 0.253$. There was also no significant main effect of screen media time above or below the AAP recommendation, $F(1, 46) = 1.393$, $p = 0.244$. There was, however, a significant interaction between condition and screen media time, $F(1, 46) = 5.303$, $p = 0.026$. The crossover interaction demonstrates that participants who watch 2+ hours of screen media per day learn better from video, and those who watch less than 2 hours a day learn better from a live person (see Figure 4). The interaction was also significant when only data from the first visit was taken into account, $F(1, 46) = 4.55$, p = 0.038. This interaction actually became stronger when other types of screen media were included (such as computers and video games) in addition to the television and video hours, $F(1, 46) = 7.769$, $p = 0.008$, and after controlling for both age and vocabulary score (using them as covariates), $F(1, 43) = 5.692$,

$p = 0.022$. The strongest interaction used all types of screen media and also controlled for age and vocabulary score, $F(1, 43) = 8.733$, $p = .005$.

Additional investigation revealed that the video deficit effect remained present only in those participants who watched less than the AAP-recommended 2 hours of screen media a day. A post-hoc test revealed that participants who watched less than 2 hours of screen media a day did learn significantly better in person than from a screen, $t(36) = 3.989$, $p < 0.001$. Participants who watched 2+ hours of screen media per day learned equally well from both conditions, $t(11) = -0.900$, $p = 0.387$. However, children that followed the AAP's recommendation and watched less than 2 hours per day did not learn better than the 2+ hours per day group across both conditions, $t(48) = 1.071$, $p = 0.289$. Therefore, we cannot conclude that children who watch less than 2 hours of television per day learn better overall. Furthermore, among children in the in-person condition (n=25), those who used under 2 hours of screen media per day learned marginally better than those who used over 2 hours per day, $t(23) = 2.061$, $p = 0.051$. Among children in the video condition, the low-exposure group learned marginally worse than the high-exposure group, $t(23) = -1.844$, $p = 0.078$. However, since we did not experimentally manipulate screen media exposure, these marginal differences are likely due to other unidentified differences between the groups other than screen media exposure.

After finding this interaction, a final 3x2 factorial ANOVA was completed to investigate at what level of exposure screen media changed children's performance on the task; this was analysis E. The participants were grouped into thirds according to their time spent viewing screen media (as described in the Research Design section, see above) and separated by their training condition (see Table 1 for distribution totals). Total correct responses on the word learning task were used as the dependent measure. There was a significant main effect of condition (in-line with the above results from a t-test), $F(1, 44) = 4.163$, $p = 0.047$. There was no significant main effect of screen media viewing time when grouped by thirds, $F(1, 44) = 1.129$, $p = 0.333$. There was also no significant interaction between condition and screen media viewing time, $F(1, 44) = 0.317$, $p = 0.73$. However, the interaction graph showed an interesting trend in the data in which the middle third of children seemed to perform better than their peers in each condition (see Figure 5). Seeing this, we collapsed the data into a simpler univariate ANOVA such that we used screen media time as the independent variable (divided into three groups by thirds) and total correct responses as the dependent variable. The ANOVA resulted in a marginally significant effect of thirds, $F(1, 47) = 6.982$, $p = 0.056$. The middle third of participants performed better on the task than both the lower and upper thirds (see Figure 6). This seemed to imply that children watching a medium amount of television and video were able to learn new words better than the rest of the participants regardless of the condition. The middle third of children spent an average of 1.08 hours per day watching TV/video. The lower third of children watched an average of 20.9 minutes per day, and the upper third of children watched an average of 2.6 hours per day watching TV/video.

Discussion

It is clear that young children are using more screen media than ever before. There is a broad debate over the implications this screen media experience has on children's cognitive development. In particular, many of the television shows aimed at children claim to support word learning. However, the video deficit effect shows that toddlers up to the age of 2 do not learn as well from a video as from a live person. I investigated how time spent watching screen media affects a child's language development. Specifically, I wanted to know how well children are able to learn new words from a screen versus a live person and how that is affected by their daily exposure to screen media sources. After finding that the video deficit did, in fact, exist in my sample of older children, I wanted to investigate why children in other populations seem to grow out of this video deficit by the same age. I hypothesized that the video deficit disappears when children have established familiarity with screen media. That is, by the age of 2, children have generally been exposed to enough screen media to have learned how to learn from it. Furthermore, in regards to the AAP's recommended time limit on children's screen media exposure, I investigated the learning differences among toddlers who follow the guideline and those who do not by dividing the children into those groups and comparing their performance on the task. Lastly, I grouped the children in the sample more evenly to determine whether there is an optimal amount of screen media use that aids children's learning.

Overall, hours spent viewing screen media did not correlate with a child's performance on a novel word-learning task. However, this sample of children did show a significant negative correlation between hours spent viewing screen media and vocabulary size. The more television parents reported their child watching, the lower the child's vocabulary score. This result is in line with previous research in which Christakis (2009) claims that there is no substantial evidence that early television exposure can improve children's language learning. Zimmerman, Christakis, and Meltzoff (2007) also found a negative correlation between videos viewed as an infant and later vocabulary size. It is possible that the parents of children who struggle with vocabulary turn to videos more often for help. It is also possible that the parents of children with smaller vocabularies are more distant and that there is a confounding variable regarding social interaction with a parent or caregiver that causes a child's vocabulary score to be lower and their amount of time spent watching television is higher. This explanation has been proposed by Christakis in 2009 as an overall reason why children should spend less time watching television, because time spent watching TV is time not spent socially interacting with other people. It should be noted that vocabulary score was also not correlated with performance on the word-learning task, so even a child's present vocabulary size does not relate to their ability to learn new words in the sample of 2½- to 3-year-olds studied. Surprisingly, vocabulary score was also not correlated with time spent reading or being read to. Although these results are interesting, it is important to stress that since these results were merely correlational, it is still an open question of what may really be causing differences in word learning ability.

However, these correlational tests do not tell the whole story regarding word-learning ability. My results indicated that a child's screen media exposure changes the nature of the children's learning in each training condition of the word-learning task. I predicted that the children in my sample would learn equally well from a video as from a live person because the video deficit has not been documented in children much older than 2. However, I found that my sample of 2½- to 3-year-old children did actually demonstrate a video deficit effect and learned significantly better in the in-person condition than from the video condition. My ANOVA results indicated that the reason for the significant difference here is the assortment of kids in my sample. The children using screen media for less than 2 hours per day retained a video deficit effect whereas the minority of kids (n=13) using screen media for 2+ hours per day learned equally well in both training conditions. Interestingly, a trend suggested that the kids who watch 2+ hours of screen media on a typical day may actually learn words better from a screen than from a live person. It appears as if those children are more used to gathering information from a screen than are children who have more limited exposure to screen media.

Other studies have drawn similar conclusions about familiarity aiding children's ability to learn from a video. A study by Barr, Muentener, & Garcia (2007) found that repeated exposure to videos in a lab setting helped children overcome the video deficit. Krcmar (2010) also found this effect in another study on the video deficit effect and word learning. The children learning words from videos performed better with repeated exposure to the video. Krcmar suggested that this effect may be due to the children's increased acceptance of the video as an informative social interaction. Along the same lines, the discounting hypothesis has been proposed as an explanation for the video deficit. It states that kids first learn that video is not relevant to them personally or that it is just for entertainment, therefore, they don't think of it as a source of information (Troseth, Saylor, & Archer, 2006). However, my results suggested that this could change with more exposure to screen media. In my sample, the effect may be that children with more experience with screen media have gotten used to it and have developed the ability to learn from it more easily. The videos may have become a type of social interaction for the children, and the children recognize a video's ability to offer useful information more than their low-exposure peers do.

The results of this study provided evidence that even though the video deficit has been documented as disappearing by the age of 2, this change may actually be due to increasing familiarity with the medium rather than regular brain development. Generally, by the age of 2, kids have seen enough screen media to realize that it can be a source of information relevant to themselves and are more able to pay attention to and learn from it. Since the composition of this sample mostly included low-exposure children, they were responsible for the video deficit showing up in the sample overall. This may also explain why areas of the country with more children that watch more screen media would find the video deficit effect to disappear once kids have gained enough exposure as a group. For example, the participants in this study watched an average of 1.1 hours of screen media per day, but participants in Linebarger & Walker's (2005) study from St. Louis, Missouri and Lawrence, Kansas exhibited that same average exposure time at only 12 months of age. Furthermore, Krcmar (2007) found an interaction between age and condition when investigating the video deficit effect. In her study, both younger (15-21 months) and older (22-24 months) children learned a novel word well from a live person, but only the older children were able to learn it from the video condition. My research would suggest that the older children in her sample must have gained enough exposure to screen media to be able to learn from the video, whereas the younger children lacked the same level of familiarity with the source.

Although the AAP cutoff did predict learning differences in the current sample, the number of kids exceeding the limitation was disproportionately small (n=13) compared to those who were obeying the limitation (n=37). Because of this, I wanted to divide the children into more equally-sized groups to get a better picture of at what point children started to exhibit differences in their performance. For example, if children watching 90 minutes per day performed more like the 2+ hour group, then the AAP could lower their recommended time cutoff. However, I found something much different from what I expected. The analysis of word learning performance across three groups of screen media exposure suggests that there is an optimal amount of television children watch. This time, instead of finding a linear relationship as described above, I found that the middle group was actually outperforming the lower and upper groups (see Figure 5). This advantage of the middle group held true among children who learned in person as well as those who learned from a video. That is, children in the middle exposure group learned better from both sources than their peers in either the low or high exposure groups. This indicates that no matter how words were presented, children who typically watch moderate amounts of screen media tended to learn novel words best. Children in the middle third may watch the right amount of screen media so that they can learn well from both live and video sources.

The results of this research indicate that the way videos affect children's cognitive development is far more complex than originally thought. Specifically, children appear to be able to adapt to new sources of information and even form preferences based on experience. Children in my sample with the most screen media exposure learned equally well from both live persons and videos. The low-exposure group of children retained a video deficit in which they learned significantly better in the in-person training condition than the video training condition. My results also indicated that there may be an optimal amount of screen media use that allows children to learn better in both conditions. These findings offer important insight into children's ability to adapt to new information sources. They also provide guidance to parents. For example, if a parent wants their child to be able to learn from screen media, then moderate amounts of exposure at a young age will help them do so. Children whose parents do not expose them to much screen media will have a harder time learning from it.

Limitations and Future Directions

One limitation to this study was a small sample size, and an especially small number (n=13) of participants who watched more than 2 hours of television a day. This could be representative of the population of 30- to 36-month olds, but I also could have encountered a sampling error. I recruited my participants from around the Boulder County area, where the culture places an emphasis on the outdoors, and it might be less socially acceptable for the parents in this environment to allow their children to watch television. The children in Boulder seem to live a different lifestyle than their peers around the country. For example, Rideout and Hamel (2006) collected a nationally representative sample of young children's everyday activities and found that 80% of children ages 2-3 played outside daily compared to 98% of the children who came into the lab for any of our projects. 37% of the children who have come into our lab never watch television compared to only 12% nationally. Lastly, only 8% of the Boulder County sample watch 2 or more hours in a typical day compared to 41% in same age group nationally. A social desirability bias also could have affected the data. For example, parents may not have wanted to admit to letting their child watch as much TV as they do. However, this issue is unavoidable, as we cannot experimentally manipulate children's at-home exposure to screen media.

My first analysis showed that the video deficit effect existed in my sample of 2.5-3 year olds. These children should theoretically show no video deficit, however, in my sample of children from the Boulder county area, the children did indeed learn significantly better from a live person than from a video. Because my sample consisted of so many low-exposure children, it makes sense that the video deficit effect would exist in the sample overall. It also explains why the deficit effect did not exist in other studies conducted elsewhere in the country where the society is less opposed to children watching television. The low-exposure children in my sample were more likely to retain the video deficit effect, and since these kids made up the majority of my sample, the video deficit effect existed overall. However, I predict that in a more balanced sample, the video deficit effect would not exist. In the future, a sample with more high-exposure children would give my analyses more power and better represent this age group throughout the country.

It is also possible, however, that there may be other differences between the high and low exposure groups aside from just their screen media time. For example, the difference may lie primarily in the type of screen media to which children are exposed. Linebarger & Walker

(2005) found evidence that shows like *Sesame Street*, *Arthur*, and *Barney & Friends* were correlated with positive effects on vocabulary and expressive language while adult programming was correlated with lower scores on these measures. Anderson and Hanson (2009) have already taken a stance that quality of screen media far outweighs quantity when it comes to children's development and learning. For these reasons, it would be interesting to take my data collection a step further and code for what shows the child watches most often. I could run similar tests on the different types of television shows (e.g. educational, entertainment, adult programming) to see whether a particular type of programming was driving the effects I found in my 2x2 ANOVA.

Another limitation of this study was that the experimental conditions provided low environmental validity. Children probably typically watch television in their own home in a living room rather than at a table in an unfamiliar building. In addition, the objects used in the word-learning task were unique to the experiment and were objects that the participants would never see in everyday life. The children might not have been as interested in learning the names of objects that they have never seen an adult or other person use or play with. Lastly, the video in the video condition was completely modeled after what the children in the live-person condition experienced and was not designed as a form of entertainment like children's videos and educational television shows, which teach words as part of a longer show meant to catch and maintain the interest of young viewers. As a future study, I could use a video designed to spark children's interest to train the children. Then I could test an in-person condition against a video condition in which the video is specifically designed for children. This method would add more environmental validity to the study and allow me to generalize my results to other settings.

Conclusions

Screen media usage is a widely researched topic in our society. The AAP's recommendation about limiting early exposure to any type of screen media has encouraged much more research in the field to determine whether this recommendation is justified. While the neural and cognitive effects of screen media viewing is unclear, there is solid evidence that very young children learn better from a live person than from a screen (Anderson & Pempek, 2005). Although this deficit disappears in the general population of children, the results of this study indicate that this is due primarily to familiarity with screen media. This means that children who watch more television develop the ability to learn from it and that children are not hard-wired to attend to a live person better than a screen. They learn to adapt to different methods of learning depending on their environment. There is also evidence that children who use a lot of screen media relative to their peers actually develop a preference for video learning versus in person learning. However, there may be an optimal amount of screen media exposure that allows children to excel at word learning from both sources. This project offers interesting insight into how children develop the skills and strategies that help them learn new information.

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	Lower 33% (0-.5 hrs)	Middle 33% (.75-1.25 hrs)	Upper 33% (1.5+ hrs)
In-person condition	N = 8	N = 10	N = 7
Video condition	N = 11	N = 3	N = 11

Table 1. *Distribution of participants when grouped by condition and screen media usage time in thirds.*

2. About how much times does your child spend on those activities in a typical day?

	Minutes						Hours				
Activity	NA	5	15	30	45	1	1.5	2	2.5	3	3+
Watching TV	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Watching a video or DVD	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Listening to music (including while riding in the car)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Playing outside	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Reading or being read to	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Playing video games like X-Box Playstation, or Wii	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Playing inside with toys	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Playing computer games	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Using a computer for something other than games	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Playing with hand-held electronic devices like iPhone, iPad, Leapfrog Platform, Gameboy, etc.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Figure 1. Survey Question. This question allows us to analyze the correlation between time spent on any of the listed activities and performance on the word learning task.

Figure 2. Novel object stimuli. The experimenter labeled each object twice using a novel name in the word-learning task.

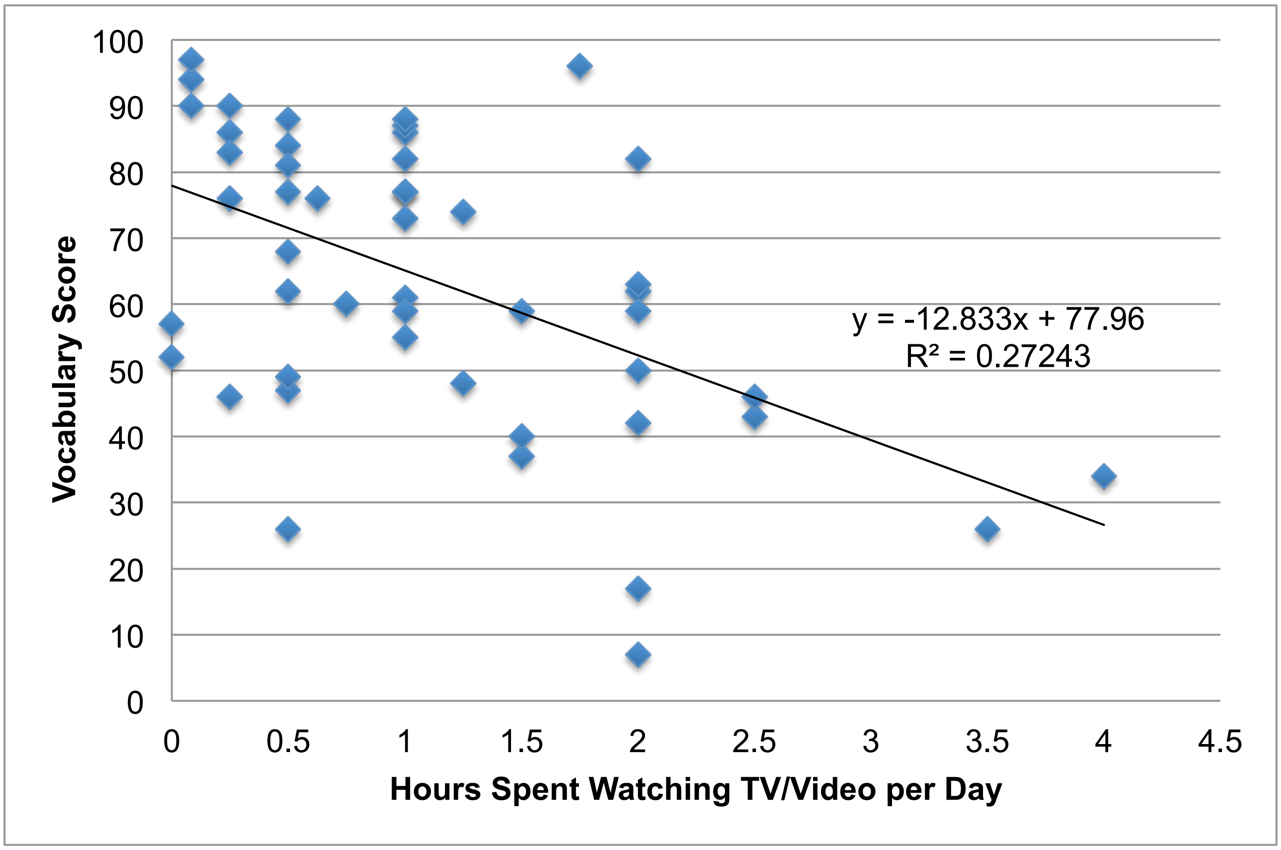

Figure 3. Correlation between screen media viewing time and vocabulary score. The negative correlation was significant, $r = -0.522$, $p < 0.001$.

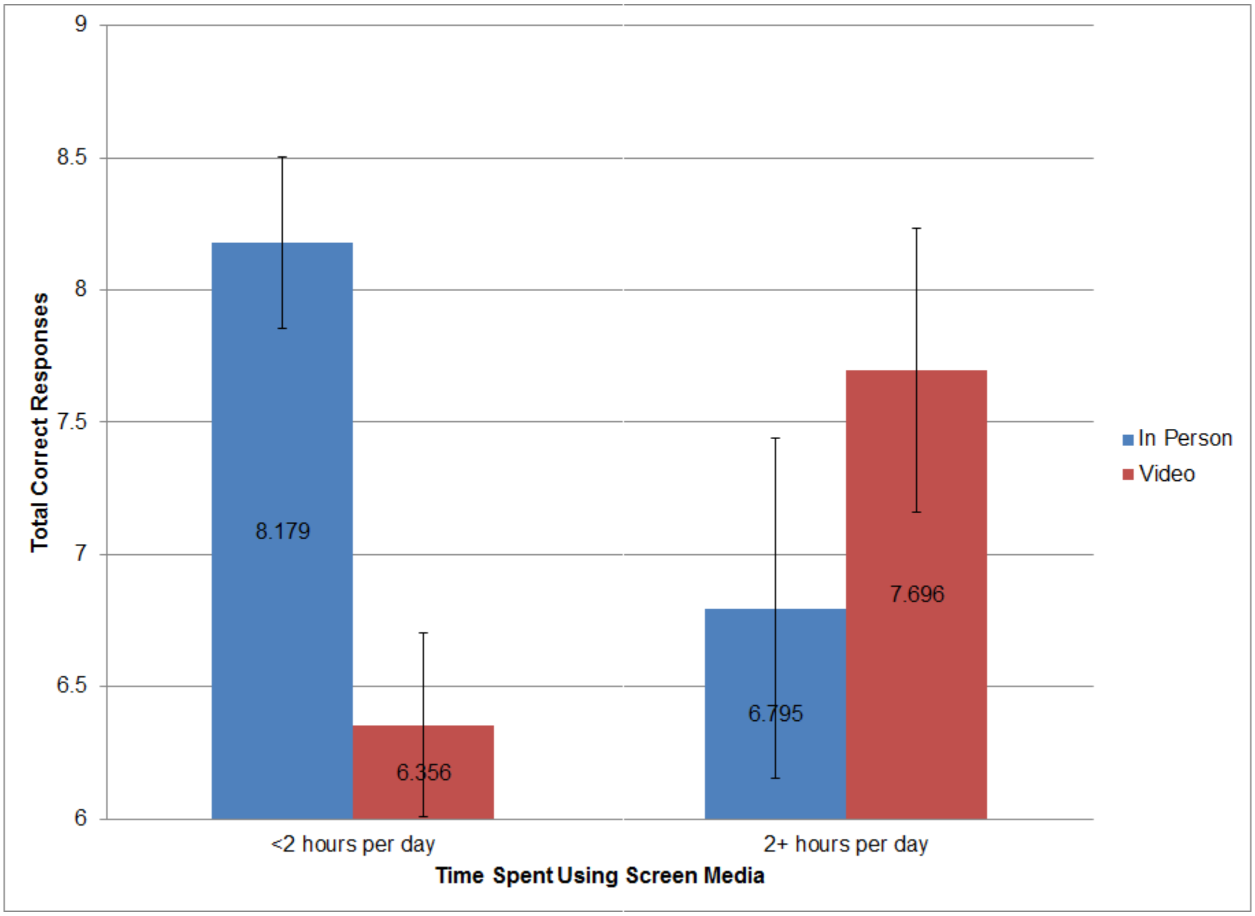

Figure 4. The crossover interaction between training condition and time spent using screen media. The interaction is significant ($p = 0.005$) after controlling for vocabulary score and age. Participants who watched less than 2 hours per day showed a significant video deficit in which they learned better from the in-person condition than from the video condition, $p < 0.001$. Participants who watch 2 or more hours per day learned equally well from both conditions, $p = 0.387$.

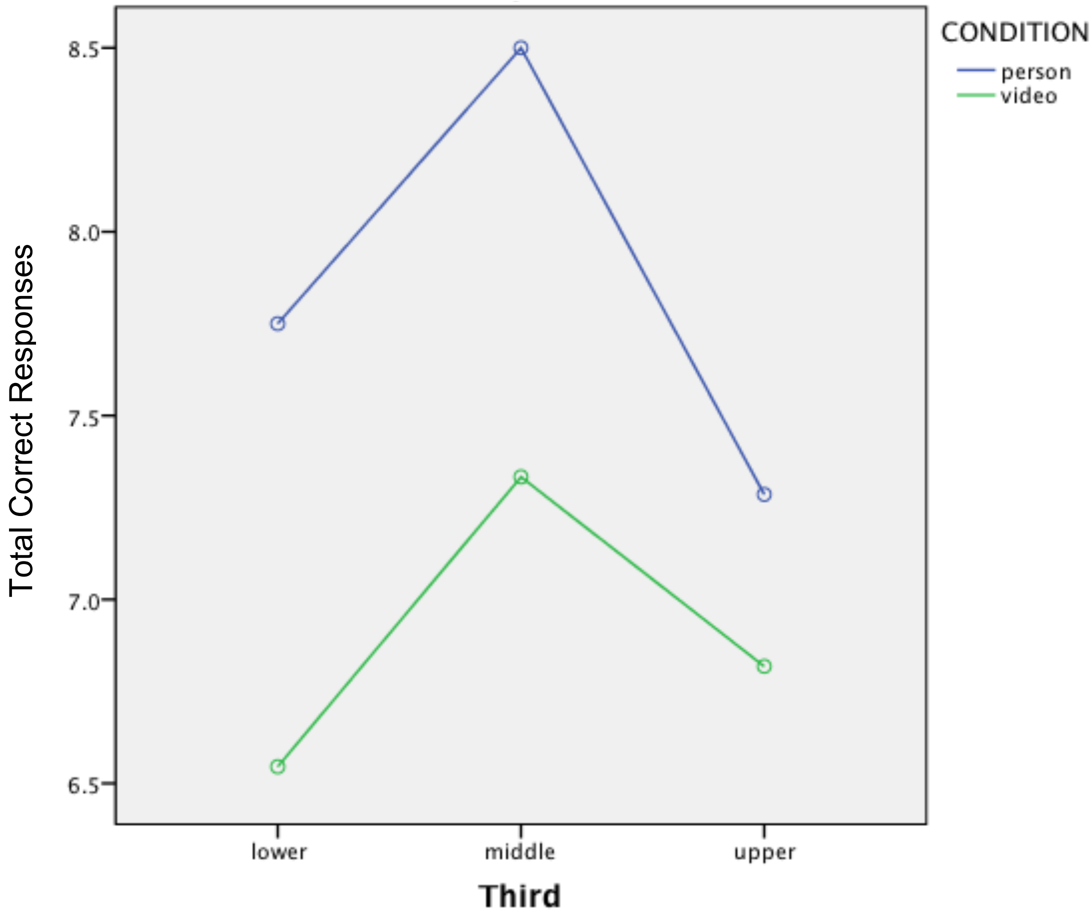

Figure 5. 2x3 ANOVA between screen media exposure time, condition, and performance on the word learning task. There was a significant main effect of condition (in-line with the above results from a t-test), $p = 0.047$. There was no significant main effect of screen media viewing time when grouped by thirds, $p = 0.333$. There was also no significant interaction between condition and screen media viewing time, $p = 0.73$. However, there was a pattern in which children in the middle third performed best in both conditions.

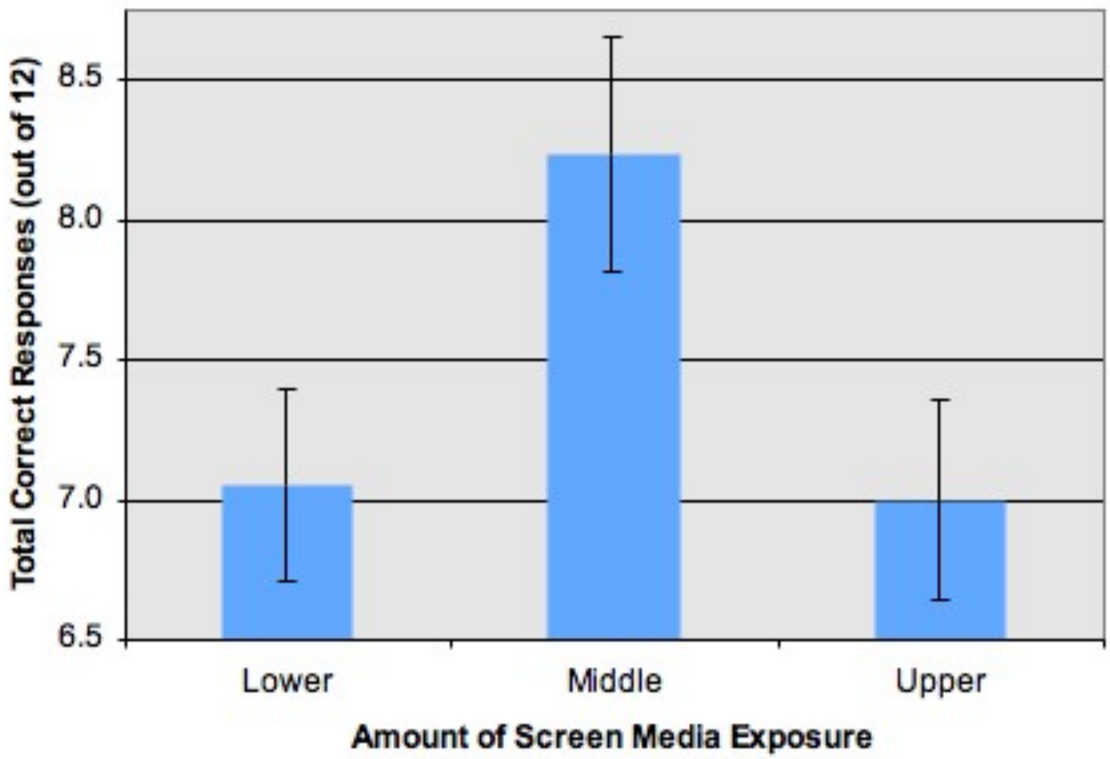

Figure 6. Performance on the word-learning task for groups of varying exposure to screen media. Children in the middle third of the dataset watched between .75 and 1.25 hours of screen media per day and performed marginally better on the word-learning task than both their higher-exposure and lower-exposure peers, $p = .056$.