4-5-2021

The Impact of Technology on the Developing Visual and/or Auditory Memory in School-Aged Children

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Andrews University

HONS 497

Honors Thesis

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April 5, 2021

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Abstract

This study aimed to determine whether time spent on technology impacts the developing auditory or visual memory in school-aged children. A survey was completed with the child participants to acquire a catalog of time spent on both technological devices and non-technological activities. Tests included a visual and auditory memory assessment adapted from the Preschool Language Scales Fifth Edition (PLS-5). The results indicated that there was no significance between the time spent on technology and the visual and auditory memory scores. However, the researchers did find that the auditory mean scores were significantly different from the visual mean scores across the participant's age range.

Introduction

Technology is becoming more accessible, widespread, and customary in our everyday lives. With this prevalence, children are commonly introduced to technological devices at a very young age. This has caused concern in the research community, especially in regards to technology's impact on childhood development. Unfortunately, the full effect of technology on children is still unknown.

Current research indicates that an increased use of technology is negatively impacting various areas of life. A recent study revealed that children, ages three to five, who have an increased use of technology, also have a lower and more disorganized development of white matter in their brains. White matter is significant because it is the location of language, literacy, and cognitive skills development (LaMotte, 2019). Another study showed that children exposed to technology close to bedtime had decreased sleep duration and quality, and increased body mass index (Fuller et al., 2017).

Unfortunately, there has been little research conducted that specifically involves technology's effect on the developing visual and auditory memory in children. This study aims to provide additional information concerning the correlation between the amount of time spent on technological devices and a child's developing auditory and visual memory skills.

This research project is a continuation of a preliminary study conducted by J.N. Andrews Honors scholar Caitlin Lopez and Dr. Darah Regal, AuD, CCC-A. Based on their findings the following changes were made: the survey regarding time spent on technology—which was given to the parents—was completed with the child participant at the time of testing, the age range was expanded to include older children who might have a better understanding of what is being asked of them and therefore perform better on the tests, questions about whether the child receives special education services or if English is a second language were added to the survey, and the age of onset for each activity was added to the survey to be used for further statistical analysis (Lopez & Regal, 2019).

The research questions for this study were: (1) Is there a relationship between the participant's use of technology and performance on the visual and auditory memory tasks?; and (2) How does a child's visual memory compare to their auditory memory during their school-aged years? The hypotheses for this study were: (1) If the child

spends more time on technological devices than on non-technological tasks, then the child will have increased visual memory skills as well as decreased auditory memory skills; and (2) The participants will present with better visual memory scores than auditory memory scores across this age range (Bigelow & Poremba, 2014; Lopez & Regal, 2019).

Methodology

Participants

Seven schools were invited to participate in the research project, six schools expressed interest, and four confirmed their participation in the project. The four schools that indicated their intent to participate in the project were Spencerville Adventist Academy and Atholton Adventist Academy, which are both located in Maryland; and Village Seventh-Day Adventist (SDA) Elementary School and Ruth Murdoch Elementary School, which are both located in Michigan. The project was advertised through email to the children's parent(s) by their school principal and the consent forms were collected at the school's front office.

Approval to conduct this research was received by the Institutional Review Board on January 28, 2020, through the Office of Research and Creative Scholarship at Andrews University. The parent of every child that participated signed an informed parent consent form. At the time of the survey and tests, the child was asked to acknowledge their consent, or understanding of the project, before they participated in the research project.

Participant Characteristics

Unfortunately, due to COVID-19, only data from seventeen students at Village SDA Elementary School was collected. The remaining three schools moved to remote learning and thus rendered data collection impossible to complete. The idea of creating an online format for data collection was considered. However, it would have caused too large of a discrepancy among the results and the researchers decided to simply work with the data that had already been collected.

Therefore, the data did not include Pre-school aged children who would have fallen into the four and five-year-old category. The study's original goal was to include four to ten-year-old children.

All testing took place onsite at Village SDA Elementary School and was collected by the student researcher and research assistant Megan Napod. It was recommended by the IRB Office that another individual be present during data collection to ensure the safety of the research participants.

The children ranged in age from six to ten, with a mean age of eight. The majority of the children were female (9/15). The highest grade-level participation was from the 3rd grade (5/15), the second was from the 4th grade (4/15), and the remainder was from the 1st grade (3/15), Kindergarten (2/15), and the 2nd grade (1/15). The majority of the children answered with English as their first language (11/15). The remainder stated that their first language was Spanish (2/15), Portuguese (1/15), and German and Portuguese (1/15). The two children who answered with Portuguese were sisters and both were likely exposed to German. All of the second or third language learners reported that English is the language they speak in school and that they understood what was being asked of them. The researchers used this to confirm that the students had a good enough understanding of English to answer the study questions and perform the tasks effectively.

Instrumentation

The instruments used for this study were adapted from a previous Honors Thesis (Lopez & Regal, 2019). Lopez and Regal's project focused on the effect of technology on visual/auditory memory and behavior in preschoolers. The methods included a survey that was completed by the child participants' parent(s) regarding the amount of time the

child participants spend daily on technological devices versus visual/auditory activities and play, an auditory memory assessment, a visual memory assessment, and a tally system for recording both positive and negative behaviors after each auditory and visual test trial. The results indicated trends that supported the hypothesis that "if a child spends more time on technology, then they will have improved visual memory skills and decreased auditory memory skills" (Lopez & Regal, 2019). Lopez also expected to see an increase in negative behaviors when time spent on technology increased. However, the results demonstrated an opposite trend to the prediction concerning behavior.

The current researchers revised and expounded upon the preliminary survey and tests in consideration of Lopez and Regal's recommendations (Lopez & Regal, 2019). The overall blueprint of the project including its procedures, general hypothesis, the research questions, and the auditory and visual memory tasks remained the same. However, the age range, the materials used for the auditory and visual memory tasks, and the methods of scoring were expounded upon. The components and programs utilized for the survey, the institutions involved, and the statistical analyses used were changed. Lastly, the behavioral element in the previous study was eliminated.

The tests included a visual and auditory memory assessment adapted from the Preschool Language Scales Fifth Edition (PLS-5). The subtests were expanded upon in order to incorporate an auditory element. This standardized test is designed to examine preschooler's auditory comprehension ability and is used for identifying children who may need additional testing in their speech and language abilities (Zimmerman, 2011). Through evidence-based investigation, the PLS-5 has been proven to be both reliable and valid. From this test, the concept of a flipbook, an incrementally increasing number of pictures, facing the client, and pointing to the desired picture to be recorded as a response in the project were implemented.

The visual memory test is validated through the work of Lauren Cole who created an identical test (Cole, 2017). The accomplished researcher published the game through a company that is a part of the University College London Institute of Education EDUCATE Program.

The auditory memory test is validated by the efforts of Casalini et al. (2007) who conducted a study using the repetition of real word strings in their procedures.

Procedure

A survey asking questions involving the amount of time spent on technological devices and non-technological activities was completed with the child at the time of testing. The results were quantified for statistical analysis.

For the visual test, the child was asked to look at a page with one picture. Next, they were shown a new page with the same picture and a new picture. The child was then asked to point to the picture that they previously saw. The test continued to increase incrementally until the child was unable to answer 50% or more correctly or they reached the end of the test, which was ten images out of a field of twenty. Two practice trials were provided to confirm that the child understood what was being asked of them.

For the auditory test, the child was asked to repeat a spoken word back to the researcher. Next, they were asked to repeat two words back to the researcher and so on. The test continued to increase incrementally until the child was unable to answer 50% or more correctly or they reached the end of the test, which was ten words that must be repeated back to the researcher. Two practice trials were provided to ensure the child understood the task.

Data Analysis

Data was imported from Microsoft Excel into IBM SPSS Statistics for Windows, Version 24. Before conducting any statistical analysis, some of the data was re-coded for age range, time spent on technology, and correct scores on the visual and auditory memory tasks.

Numerical and visual inspection of the data determined that nonparametric statistical analysis would be used to answer the research questions because the study's sample size was small, the data were skewed and the data were placed in unequal age groups.

Results

Question 1: Is there a relationship between participants' use of technology and performance on the visual and auditory memory tasks? It was hypothesized that if the child spends more time on technological devices than on non-technological tasks, then the child will have increased visual memory skills as well as decreased auditory memory skills (Bigelow & Poremba, 2014; Lopez & Regal, 2019). A Spearman rank-order correlation coefficient (rho) test was conducted to show the relationship between the time spent on technology and the participants' performance on visual and auditory tasks. Based on the results, there was no association between the participants' time spent on technology and their performance on visual memory tasks, $r_s = .418$, $p = .121$, and their performance on auditory memory tasks, $r_s = -.042$, $p = .881$. See Table 1 (Spearman's rho Correlations).

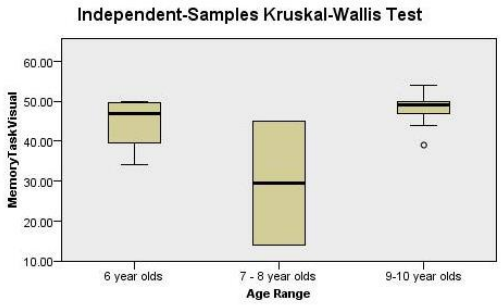
Table 1

Spearman's rho Correlations

		TimeSpent_Tech	CorrectV	CorrectA
Time Spent_ Tech	Correlation Coefficient	1.000	.418	-.042
	Sig. (2-tailed)	.	.121	.881
	N	15	15	15
CorrectV	Correlation Coefficient	.418	1.000	.331
	Sig. (2-tailed)	.121	.	.228
	N	15	15	15
CorrectA	Correlation Coefficient	-.042	.331	1.000
	Sig. (2-tailed)	.881	.228	.
	N	15	15	15

Question 2: How does a child's visual memory compare to their auditory memory during their school-aged years? It was hypothesized that the participants will present with better visual memory scores than auditory memory scores across this age range (Bigelow & Poremba, 2014; Lopez & Regal, 2019). An Independent-Samples Kruskal-Wallis test was conducted to show a difference in the participants' scores on the auditory and visual memory tasks by age. There was no significant difference of means on the visual memory task ($H = 3.074$, $p = .215$). See Figure 1 (Independent-Samples Kruskal-Wallis Test), Table 2 (Kruskal-Wallis Test Statistics).

Figure 1, Table 2

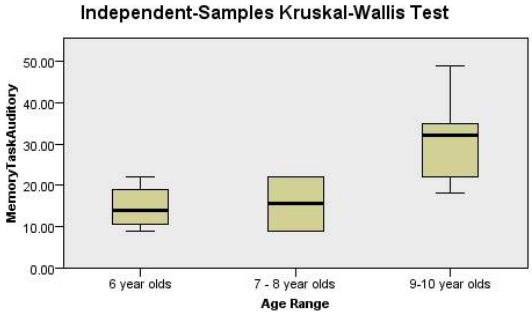


Total N	15
Test Statistic	3.074
Degrees of Freedom	2
Asymptotic Sig. (2-sided test)	.215

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

However, there was a significant difference of means on the auditory memory task (H = 6.809, p = .033). See Figure 2 (Independent-Samples Kruskal-Wallis Test), Table 3 (Kruskal-Wallis Test Statistics).

Figure 2, Table 3

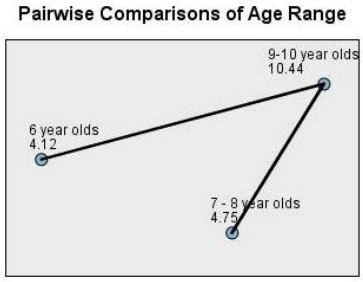


Total N	15
Test Statistic	6.809
Degrees of Freedom	2
Asymptotic Sig. (2-sided test)	.033

1. The test statistic is adjusted for ties.

Post hoc tests were conducted to test pairwise comparisons. The findings showed that the youngest group's (six-year-olds) performance on the auditory and visual memory tasks was significantly different from the oldest group's (nine and ten-year-olds) performance (p = .018). The youngest group (six-year-olds) and the young group (seven and eight-year-olds) were not significantly different (p = .871); nor was the young group (seven and eight-year-olds) to the oldest group (nine and ten-year-olds) significantly different (p = .102). See Figure 3 (Pairwise Comparisons of Age Range), Table 4 (Average Rank of Age Range).

Figure 3, Table 4



Each node shows the sample average rank of Age Range.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
6 year olds-7 - 8 year olds	-.625	3.856	-.162	.871	1.000
6 year olds-9-10 year olds	-6.319	2.675	-2.362	.018	.055
7 - 8 year olds-9-10 year olds	-5.694	3.480	-1.636	.102	.305

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

Discussion

For both the auditory and visual tasks, the basal and ceiling did not appear to be too easy or too difficult. All of the data collected were recorded in the middle of each task, with each participant easily passing the basal with two practice trials, and the ceiling was not repeatedly reached.

The participant motivation was fairly good. The participants appeared happy to play a game in the middle of their school day. They all wanted to do well on the tasks and tried their best to reach the end of each of the tasks. However, the auditory task appeared to be more challenging than the visual task. So, to increase motivation, provide a feeling of

accomplishment, and alleviate any threat to the internal validity of the project, such as participant bias or threat of testing effects, the researchers switched the order of the tests from the visual task first and the auditory task second to the auditory task first and the visual task second. Therefore, the participants would leave the assessment with a feeling of success and pride in their efforts.

Lastly, the researchers would like to note that the participants spent a shorter amount of time on technology than expected. Approximately half of the participants—six to eight children—recorded spending time on technology (e.g. using a smartphone, spending time on a computer, playing on a tablet, etc.) for only 20-30 minutes a day. Very few children referenced watching TV or using a gaming system. About half of the children reported spending time on a computer system with times ranging from ten minutes to an hour. On average, about 40-60% of the children mentioned using any type of technological device from as short as five minutes to as long as one to two hours, with the majority of the children falling on the shorter end of the spectrum. Thus, with this limited use, in addition to the small sample size, the researchers were not surprised that technology had no statistically significant impact on both the auditory and visual memory scores. They believe that if their sample size was larger, then they would have had a more diverse representation of technology use and been able to see an association between technology usage and visual and auditory memory scores.

Conclusion

Previous research states that when technology replaces unstructured play and other valuable developmental activities, it negatively affects the development of language and other cognitive skills in children (LaMotte, 2019; Lee, 2016; Radesky & Christakis, 2016). Consequently, the researchers used these findings to craft their research questions and hypotheses for this study.

Question one sought to answer whether there is a relationship between participants' use of technology and their performance on a visual and auditory memory task. The results found in Table 1 (Spearman's rho Correlations) showed that technology had no impact on the scores of both the visual and auditory memory tasks. This could be because there is no association, the sample size was too small, or because the groups were unequal. Therefore, the researchers accept the null hypothesis for their first research question.

Question two attempted to answer how a child's visual memory compares to their auditory memory during their school-aged years. The results found in Figures 1 and 2 (Independent-Samples Kruskal-Wallis Test) and Tables 2 and 3 (Kruskal-Wallis Test Statistics) indicated that there was no significant difference between means for the visual test, but there was a significant difference between means for the auditory test. Thus, the researchers accept their hypothesis that visual scores will be better than auditory scores across this age range.

The results found in Figure 3 (Pairwise Comparisons of Age Range) and Table 4 (Average Rank of Age Range), which attempted to further investigate age range differences and scores on both the auditory and visual tasks, demonstrated that there is a significant difference across this age range. The youngest group's (six-year-olds) scores were significantly different from the oldest group's (nine and ten-year-olds) scores. However, there was no significant difference between both the youngest group and the young group (seven and eight-year-olds) and the young group and the oldest group. This furthers the acceptance of the researchers' hypothesis for their second research question.

Unfortunately, technology did not prove to have significance in this study, but this could be a consequence of several factors. One particular factor, which the researchers

would like to point out, is that the participants in the study stated that they spent a shorter amount of time on technology than expected. If the researchers' sample size had been as large as intended, likely children who spend a longer amount of time on technology would have been included in the study. This would improve the study's overall ability to look at technology's effect on both visual and auditory memory. However, the results did indicate that age has an influence on both auditory and visual memory. Therefore, the researchers believe that this area of research is important for understanding visual and auditory memory development at this age, and that technology could remain a factor in childhood development.

Limitations

The study suffered several limitations. First, the children that participated in the study scored far lower in the amount of time spent on technology-related activities than expected. A larger sample size from a more diverse population, in the sense of environment and upbringing, would have greatly improved the quality of the correlation between time spent on technology and both the auditory and visual memory tasks.

Second, and very closely related to the first limitation, the small sample size was from only one location. The intended participation from the other three schools located in two separate states would have given the researchers a more widespread, and likely more accurate, interpretation of the amount of time school-aged children spend on technology. Participation from more students would also have likely added to the number of children in each grade level and assisted in correlating the different age ranges.

Third, it is difficult to know whether the children had a reliable understanding of the length of time that they reported they spend on the different activities addressed in the survey. It would be highly beneficial to have parent input included, in addition to the child's answers, to add to the child's reliability of their responses.

Fourth, both the auditory and visual tests are not standardized and therefore their reliability and validity cannot be confirmed.

Fifth, more information could have been collected regarding English as a second language and whether the children fully understood the English language, or were simply familiar with it because they attend an English-speaking school.

Finally, the questions regarding the type of technology should be formatted to either include all types of technology or only focus on specific kinds of technology (e.g. only TV or only gaming systems). This would ensure a better research methods design to enable easier and better data analysis for the research questions.

Further Research

The aim of this study is highly relevant and important for understanding how technology may be impacting childhood development. The researchers encourage the research community to continue to investigate all aspects of technology and its influence on children and their development.

Moving forward, this study's sample size could be used to project how many children should be used in a similar study in the future. It is recommended that a larger and more diverse sample be used to encompass an accurate representation of school-aged children. Also, this study, with a larger and more diverse sample, could potentially establish normative data to compare auditory and visual memory at different ages.

Additionally, it is recommended that a standardized test be used to record working memory overall, instead of separating memory into auditory memory and visual memory. In an article written by Gonthier et. al. (2017), the authors provide a free, ready-made test called ACCES that can be used to assess the working memory in children ages eight to

thirteen and it takes about 30 minutes to complete.

Acknowledgments

Special thanks to Dr. Darah Regal, Dr. Shandelle Henson, and Mrs. Laura Carroll who saw the vision for this project and assisted with the initial steps to bring it to actuation. Gratitude is expressed to Dr. Pittman and Mrs. Maxine for their continued aid and guidance throughout the process of this project. The Office of Research and Creative Scholarship, the J.N. Andrews Honors Program, and the School of Communication Sciences and Disorders are also recognized for their generous support of this research project. Kind acknowledgment is expressed to the principals of each of the schools involved or intending to be involved for their readiness to be a part of this project. Lastly, the efforts of Dr. D'Jaris Coles-White are deeply appreciated for her willingness to join the project, assist with the statistical analysis, and provide valuable advice throughout the process of this project.

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