
# B.Sc. Psychology

The Impact of Computer- and Smart-Device Use on Cognitive Function: Differences between Passive- and Interactive Screen-Use

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## Abstract

The aim of this pilot study was to explore screen-use and its possible impact on cognitive function. Total time spent on devices as well as different types of use were considered. The sample consisted of 40 participants, two of which were not students. The other 38 were either undergraduate students from Reykjavik University or the University of Iceland. The participants completed a Logical Memory test where both immediate and delayed recall was tested. They also completed a Stroop Color-Word test and filled out an electronic questionnaire focused on smart-device use. The results showed significant main effects of both cognitive tests (better performance on the easier parts of the tests). Interaction effects between Stroop and total screen use were not significant. More time spent on passive activities was connected to worse performance on the delayed recall as well as on the more difficult parts of the Stroop task. However, more interactive activities were not linked with better performance on cognitive tests. The results suggest that computer use, and particularly passive screen-activities may be linked with poor cognitive functions. As the sample is homogenous and small, more research on the subject is needed.


*Keywords: smart-device use, smart device activities, screen-use, cognitive function, stroop, logical memory immediate recall, logical memory delayed recall*


Þessi rannsókn var gerð til að skoða möguleg tengsl skjááhorfs við hugræna getu. Heildartími áhorfs var skoðaður ásamt tegundum tölvu- eða snjalltækjaathafna. Úrtakið samanstóð af 40 þátttakendum, tveir af þeim voru ekki nemendur. Hinir 38 voru í grunnnámi í Háskólanum í Reykjavík eða Háskóla Íslands. Þátttakendurnir tóku tvenns konar hugræn próf: Logical Memory, minnispróf þar sem mælt var bæði skyndiminni ásamt seinkuðu minni, og Stroop prófið sem mælir athygli. Einnig fylltu þátttakendur út spurningalista þar sem spurt var út í tölvu- og snjalltækjanotkun. Niðurstöður sýndu marktæk meginhrif fyrir bæði hugrænu prófin (betri frammistöðu á auðveldari prófum). Samvirknihrif voru ekki marktæk á milli Stroop og skjátíma. En meiri skjátími sem samanstóð af athöfnum sem töldust óvirkari athafnir (s.s. sjónvarpsáhorf) virtust hins vegar tengjast verri frammistöðu á hugrænu prófunum. Ekki sást marktækt betri frammistaða hjá þeim sem settu meiri tíma í virka skjánotkun. Samkvæmt þessu virðist mikil skjánotkun tengjast slakari hugrænni getu. Þó niðurstöður bentu til athyglisverðra tenglsa þá þarf að huga að takmörkunum þessarar rannsóknar. Það þarf stærra úrtak og fjölbreyttara til þess að fá skýrari mynd af því hvort magn skjátíma hafi einhver tengsl við skorun á prófum sem eiga að mæla hugræna getu.

## Foreword and Acknowledgements

This thesis is submitted in partial fulfillment of the requirements of the BSc Psychology degree, Reykjavik University. This thesis is presented in the style of an article for submission to a peer-reviewed journal.

I would like to note down my gratitude. First towards my supervisor Kamilla Rún Jóhannsdóttir, who was of great assistance throughout the research project. I would also like to pass on my thanks to Brynja Björk Magnúsdóttir, who provided one of the tests and shared her experience. Finally, I'd like to thank my parents for their support and of course my husband for his love and support. Without him taking great care of our newborn daughter I could not have finished the project on time.

# The Impact of Computer- and Smart-Device Use on Cognitive Function: Differences between Passive- and Interactive Screen-Use

Today smart-devices are very popular in our society. Internet use in Iceland has increased to a point where in 2014, 95% of the population had become regular users of the internet (Statistics Iceland, 2014). Iceland therefore has the highest percentage of internet users in Europe, the average within the European Union being 72% (Statistics Iceland, 2014). Given the high percentage of internet use, and as a result the increased time spent on smart-devices, the effects screen-use may have on cognitive function is an interesting research topic. Cognitive function is a broad term used for a variety of skills such as memory, processing speed, attention, intellectual capacity and concentration, to name some. The present study focused on memory and attention only. The aim of this study was to examine the amount of screen use among university students in Iceland to see whether their performance on known cognitive tests differed depending on their screen time. The aim was further to examine if the type of screen use (passive- or interactive activities) mattered in relation to performance on the cognitive tests.

A repeatedly stated fact in relation to screen-use and especially in relation to computer gaming or television watching is how these activities influence sedentary lifestyles (Janssen, 2016). It is important to be physically active and studies on health show that sedentary lifestyles can be unhealthy for people (Janssen, 2016; Lacy et al., 2012; Tremblay, Colley, Saunders, Healy, & Owen, 2010). People need to balance the amount of sitting done at work or elsewhere with forms of physical activity (Janssen, 2016). A study which focused on this sedentary topic in relation to computer games or TV watching among children suggested more physically involved computer games to battle the problem (e.g. Dance Dance Revolution), as well as the use of treadmills while watching television. This showed positive results on post-administered tests

which assessed well-being (Lanningham-Foster et al., 2006). Cajochen and colleagues (2011) pointed out that screen-use can have effects on people's circadian rhythms. The LED light emitted from screens can have a disrupting effect on sleep, but may also have an enhanced effect on alertness and cognitive performance (Cajochen et al., 2011). Many things have been studied in relation to screen use and possible effects, but the link between everyday computer use and cognitive performance or academic achievement has not been well studied.

Zimmerman and colleagues (2005) used data from a nationally representative data set with the objective to look at effects of television watching on reading skills among children of 6-7 years of age. They explored data on the kids' TV watching before the age of 3 and between ages 3-5. They found that each hour of average daily television viewing before the age of 3 was associated with 0.31 fewer points on the Peabody Individual Achievement Test Reading Recognition scale at 6-7 years of age. Scoring was also worse on the Peabody Reading Comprehension Scale, each hour connecting to 0.58 fewer points. The reading recognition scale showed a beneficial effect of television watching at ages 3-5 where each hour was associated with 0.51 points increase on that scale. The researchers concluded that TV watching has detrimental effects on academic performance (Zimmerman & Christakis, 2005).

Even if screen-use has bad effects the activity being performed may have positive outcomes. There are hints of good effects of computer activities on cognitive function. In relation to the elderly, a research project that focused on cognitive function in relation to smart-device use showed positive results (Vaportzis, Martin, & Gow, 2017). After spending a certain number of hours on the device every week, the participants scored higher on a post-administered cognitive test assessing processing speed than on the test pre-administered test (Vaportzis et al., 2017).

Some studies do not suggest TV or computer gaming to be linked to bad effects on school

performance or attention (Ferguson, 2011). The aim of Ferguson's study was to explore not only television and video game use but also other variables that could be risk factors for attention problems and poor school performance. Their participants were 603 children of the age 10-14 and those children's parents or guardians. The participants filled out questionnaires that included questions about attention problem behaviors from a Child Behavior Checklist. School performance was measured by the children's grade point average (GPA). The results showed that male gender, antisocial traits, family environment and anxiety best predicted attentional problems of the measured variables. Family income was the best predictor in relation to school performance. Television and video game use were not predictors of attentional problems or lower GPA (Ferguson, 2011). Patterson & Patterson (2017) also studied school performance but in a college sample. They used a natural college environment where teachers got to decide whether laptops were prohibited, optional or allowed in their classrooms. The study's aim was to explore differences in grades depending on whether laptops were used in the classes or not. The student population included 5571 students over a course of six semesters, and most of them took multiple courses with differing laptop policies. They filled out a questionnaire on their laptop use in each class. Results showed that on average students got lower grades in the courses where they used laptops (Patterson & Patterson, 2017).

When it comes to computer gaming, studies with the aim of exploring influential effects show varied results (Bailey K., West R., & Anderson C. A., 2009; Sanchez, 2012). Bailey and colleagues (2009) recruited 51 men between 18-33 years of age to their study. The sample was split into a low-gaming group (M = 1.76 hours a week) and a high-gaming group (M = 43.4 hours a week). The Stroop task was used to test reactive control, but the men were also hooked up to an electroencephalogram (EEG) and the readings were used to assess proactive control

during the task. There was no difference between high- and low-gaming groups when looking at the reactive response time on the task. However, the EEG data suggested that the high-gaming group was slower to adapt on the task than the low-gaming group. In other words, it seems that video game experience may link to a negative influence on proactive cognitive control. Sanchez (2012) explored computer gaming by testing 60 university students on visuospatial abilities before and after 25 minutes of computer game training. The aim was to see if visuospatial assessments could be enhanced with relevant training, and if it produced a noticeable increase in science learning that related to visuospatial ability. Participants completed a volcano concept pretest which evaluated prior understanding of plate tectonics. Then they completed paper folding and card rotation pretests to test visuospatial ability. A working memory capacity test was also completed to control for differences in cognitive ability. Participants also filled out a game experience survey on previous game experience. The sample was divided into two groups for different types of computer game training, one spatial-training group (n = 40, 40% female) that played Halo: Combat Evolved, a first-person shooter game. The other was a non-spatial training condition group (n = 30, 36,7% female), they played a game where the goal was to make words out of a group of letters to earn points. Afterwards participants read a text on plate tectonics. It included five major concepts that participants had to explain in a written essay. They got points from 0-5, one for each major concept they explained. Finally, they completed a part two of the visuospatial tests that were pre-administered. Results suggested that playing games where visuospatial skills were more in use linked to better scores on post-administered visuospatial tests. It also had an impact on performance in content areas where visuospatial skills were utilized.

In sum, effects of screen-use are often considered bad. Watching television has been linked to worse reading skills among kids (Zimmerman & Christakis, 2005). Using laptops in college classes has shown worse grades in those classes (Patterson & Patterson, 2017). Though some studies suggest that other variables, such as family income, matter more in relation to academic achievement among kids (Ferguson, 2011). Screen-based activities may also be helpful sometimes. Elders' scores on processing speed tests have benefitted on tablet training (Vaportzis et al., 2017) and visuospatial skills seem better among gamers who play first person shooter games than those who do not (Sanchez, 2012). Every-day screen-time and cognitive function hasn't been researched much however. Neither has the type of screen-based activities people spend their time on and differences in effects depending on these activities.

## The present study

The present project was a pilot study on the potential link between screen-use and cognitive functions. Cognitive function was assessed only in relation to attention and memory. Total amount of screen-use was measured but also the types of screen-based activities participants spent their time on. The activities were grouped into passive activities (i.e. television viewing and social media browsing) and interactive activities (i.e. studying and computer gaming). Based on previous research it was expected that those who used screens more would have a slower response time on the Stroop Color-Word task, and lower scores on the Logical Memory test than those who spent less time on screen-based activities. In addition, it was also tested whether the link between cognitive performance and screen use varied depending on whether the screen-use was on passive- or interactive- activities.

# Method

## Participants

Recruitment for the study was done by posting information about the study in a Reykjavik University Psychology group on Facebook. The sample consisted of 40 participants, 13 men and 27 women from 20 to 31 years old (M = 24). There were 33 students from the first two years of the undergraduate psychology program at Reykjavik University. These students were from the Psychology department's research participant pool, and therefore they received course credit for participating. Seven total participants were not part of the university's research participant pool. Four of them were 3rd year psychology students, one was a student from the University of Iceland and two were not students. Those who were not part of the research pool did not receive any payment for their participation. People with serious cases of dyslexia were not recruited to the study.

## Instruments

**Logical Memory.** An Icelandic version of Logical Memory was used to test immediate and delayed memory recall. Logical memory is part of the Wechsler Adult Intelligence Scale known as WAIS. It is used to assess memory but often in clinical samples (Wechsler, 1945). Generally Logical Memory consists of two stories which are read to subjects, but as this sample did not include clinical subjects with impaired memory, only the more challenging story was used. The story was approximately 90 words. It was about a man who was preparing to go out but changed his mind due to a bad weather report on the television. The story was only read once, then the immediate recall was tested straight after the reading and then delayed recall was tested after approximately 15 minutes. The recall was tested with free recall, the participants retold the story as close to the original as they could, and the researcher noted down what they

remembered. Score was then calculated based on precise words they got right when retelling the story. Generally, scores are also calculated for remembering the theme of the story. Everyone scored 6 or 7 (scale from 0-7) on that which is understandable as none of the participants had clinical memory problems. Due to everyone scoring so high the theme score was not analyzed further. Reliability is usually not calculated for logical memory alone but for WAIS in whole. The WAIS is commonly considered to be reliable in clinical assessment (Parker, Hanson, & Hunsley, 1988). Parker and colleagues (1988) found a .86 reliability value.

**The Stroop Test**. The participants also completed a Stroop Color-Word task (Stroop, 1935) to assess attentive abilities. The task consisted of four slides that each had seven color words (yellow, red, green, blue, brown, pink and black) repeated randomly 34 times in font size 28 and in varied font colors. The font color of each word was always one of those seven colors. Participants needed to name the font color used on each of the words out loud, while ignoring the words. The researcher recorded the time it took to finish each of the four slides, as well as any mistakes the participants made. One of the slides had matching color of font to each word, while the other three slides were more difficult as they had both matching and mismatching font colors to the words. Those had either 30%, 70% or a 100% mismatching colors to words. The order of the slides for each participant was randomized with the Latin-Square method for the whole group so that the results would not be skewed due to practice effects on the same slides.

**Questionnaire.** Each participant was asked to fill out an electronic questionnaire made by the researcher and stored on SurveyMonkey. The questions were 10 in total. The first question was about the participant's number, which was drawn at the beginning of the study. The other nine questions were about gender, age, mean grade in school, main type of computer games played, if any, and finally amount and type of smart-device usage. There was a multiple-choice

question about average time spent daily on computers and smart devices. The answer choices were “less than an hour”, “1-2 hours”, “3-4 hours”, “5-6 hours” or “more than 6 hours”. There was also a question where participants had to write the number of hours they spent on specific activities. The answers were written in empty boxes next to each activity (i.e. episode- and movie watching, computer gaming, social media browsing, studying and “other” activities). The participants had to write down the hours spent on each, or “0,50” if they spent half an hour on it and “0” if they spent no time on it.

**Procedure**

After the study was approved by the Psychology department of Reykjavik University, data gathering started. The study was always performed during the day and lasted from the 5th of March until March 30th. Recruitment was done over Social Media. The ad was posted in a Psychology Facebook group intended for Reykjavik University’s students. Interested people were asked to contact the researcher if they wanted to participate. The researcher wrote down planned sessions in a closed Google Sheet, as well as in a research diary. The study was mostly performed at Reykjavik University, in the Psychology department’s research lab or in study rooms if the lab was unavailable. Two participants were tested at the researcher’s home. Only one participant was tested each time. Each participant took 15 minutes on average, the range being between 15 and 25 minutes. First the researcher handed out the informed consent form which explained the study briefly and then the participant was asked if he/she had any impairment such as dyslexia or hearing problems or any other condition they thought was worth mentioning that could intervene with the tasks. After the informed consent form had been read and signed and any questions answered, the testing began. The researcher explained each part of the study prior to each task to make sure that the participant understood what to do at each time.

A random two-digit number was then drawn which was used instead of the participant's name so that his/her answers were kept anonymous. The two-digit number was written on the researcher's scoring form and in the online survey. The first test was the Logical Memory Immediate Recall. The researcher read the story out-loud at a steady pace for the participant who was asked to try to memorize it word for word as best he/she could. After the researcher finished reading, the participant was asked to retell the story as close to the original as possible. The researcher wrote down what the participant remembered. After that the Stroop task was completed and then the questionnaire. Next the participant was asked to retell the Logical Memory story. The researcher wrote down what was remembered and later the computed score was used to assess delayed memory. The delayed recall had to be tested at the very end of the session, so that some time had passed since the story was told. Finally, the researcher expressed thanks for the participation and if there were any questions about the study they were answered.

**Data Analysis and Design**

Screen-use was assessed by computing all computer- and smart- device activity of each participant. A "total screen-use" variable was created by computing the time each participant listed down as a computer- or smart-device activity in the questionnaire. That variable was then split at the median (M = 8.5) into high usage and low usage groups (Low = 19, High = 21) so that it could be further analyzed with the Stroop and logical memory results. Two other variables were created, one of those represented passive smart-device activity: (hours spent movie/episode watching and hours spent browsing social media). That variable was also split into low and high usage groups with a median split (Low = 15, High = 25). The other variable represented interactive smart-device activity (time spent computer gaming and time spent studying) and that one was also split at the median in the same way (Low = 21, High =19). Response time was

noted down for each slide in the Stroop task and that was used as a four-level dependent variable for the Stroop test. The data was analyzed in three separate Mixed ANOVA tests. For total screen use, passive screen use and interactive screen use with the factors type of Stroop (0-100% match between color word and font) and amount of screen time (low vs. high). Three mixed ANOVA's were also conducted for logical memory, with the time (immediate vs delayed) x amount of screen time (low vs high) as the factors.

As the hypotheses specified a directional relationship between the variables, the *p* values were divided by two. When interpreting the data, the Mauchly's test indicated that the assumption of sphericity was never violated, therefore a correction was not needed. Effect sizes were also measured in the analysis (0.01-0.06 = small effect size, 0.06-0.14 = medium effect size and >0.14 large effect) (Gray, C. & Kinnear, P., 2012). Analysis was performed in IBM SPSS statistics version 24.

## Results

The aim of this study was to look at screen-use and its possible link to cognitive function. Also, to explore whether different type of screen-based activities had different effects. The data was analyzed in three 2x4 mixed ANOVA's for the Stroop test and three 2x2 mixed ANOVA's for the logical memory test. The level of significance used in the analysis was alpha = 0.05 one-tailed. The hours participants in this study said they spent on screen-based activities on average was 8.3 (Std. 2), ranging from 4.5 hours to a maximum of 13.

### Stroop Task

Looking at Table 1 below you can see descriptive statistics for the Stroop task. It shows mean response time on each of the four slides, first one being 0% mismatch of color and word, 2$^{nd}$ being 30%, 3$^{rd}$ 70% and the final one 100%. Minimum and maximum response time is also

shown along with the standard deviation. Generally, it took people the longest to finish the 30% and 70% mismatch slides. Mean time was however highest for the 70% and closely followed by the 100% mismatch slide.

Table 1.

*Mean response time on each slide of the Stroop-Color-Word task.*

| Slide | Mean | Standard deviation | Minimum | Maximum |
|---|---|---|---|---|
| 100% Congruency | 19.20 | 4.8 | 11.39 | 35.72 |
| 30% Mismatch | 24.90 | 4.7 | 16.54 | 40.03 |
| 70% Mismatch | 27.50 | 5.9 | 18.10 | 47.59 |
| 100% Mismatch | 26.45 | 4.1 | 18.47 | 38.75 |

The results of the 2x4 ANOVA revealed a significant main effect for type of Stroop, $F(3, 114) = 37.407$, $p < .001$, partial $\eta^2 = 0.5$. Interaction effects between Stroop and total screen use were not significant, $F(3, 114) = 1.590$, $p = 0.09$.

The 2x4 mixed ANOVA for screen time and passive activities showed a significant main effect of Stroop, $p < 0.0$. The main effect of the group was also significant. Significant interaction effects were also seen. $F(3, 114) = 2.408$, $p < 0.01$, partial $\eta^2 = 0{,}06$. Figure 1 below shows that those who spent more time on passive activities had a slower response time for the more difficult slides on the Stroop test than those who spent less time on passive activities.

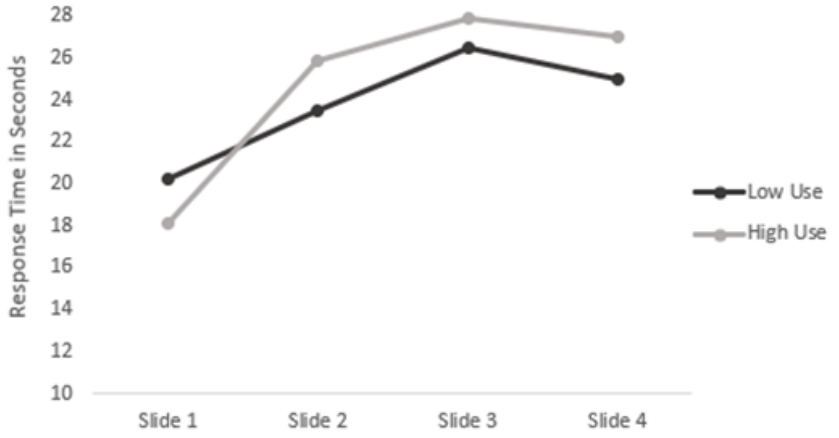


*Figure 1*. Mean response time on Stroop and an interaction effect between amount of passive screen-use and type of Stroop test.

The interaction effect between Stroop and interactive activities was close to significant $F(3, 114) = 2.015$, $p = .06$, partial $\eta^2 = .05$. Figure 2 shows a crossover interaction effect. Those in the "high use" group seemed to do slightly better on slide 1 and 2 whereas the mean response time was worse on the other 2 slides.

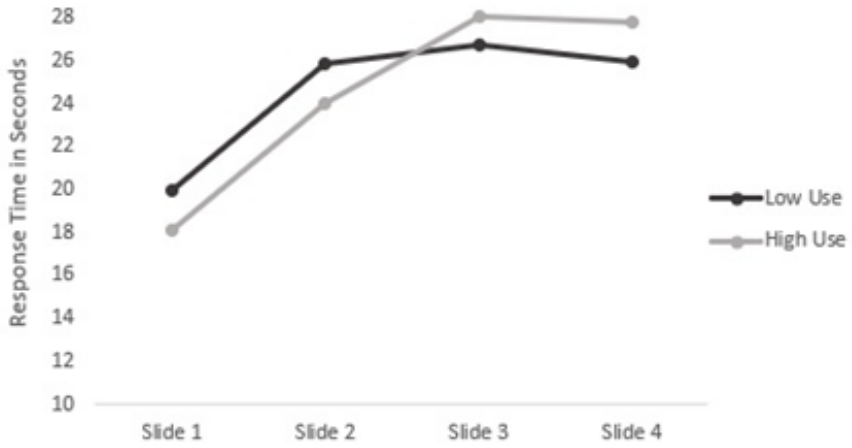


*Figure 2*. Crossover interaction effects between type of Stroop and amount of interactive Screen-Use, $p = 0.06$.

**Logical Memory**

Table 2 below shows the mean score, standard deviation and minimum and maximum scores on the Logical Memory immediate- and delayed recall. As expected, people had higher scores on the immediate recall.

Table 2.

*Mean score and distribution on the Logical Memory task.*

| Task | Mean | Standard deviation | Minimum | Maximum |
|---|---|---|---|---|
| Immediate Recall | 10.6 | 3.4 | 5 | 21 |
| Delayed Recall | 8.6 | 3.2 | 3 | 16 |

The results of the 2x2 mixed ANVOA showed a significant main effect of time $F(1, 38) = 30.324$, $p = 0.05$, partial $\eta^2 = .44$. Participants did better on immediate compared to delayed recall. The main effect of group was not significant, $F < 1$. but the interaction between time and group was significant. Figure 3 shows an interaction effect between total screen time and scores on the Logical Memory tasks. Participants who were in the high use group did worse in general on both immediate- and delayed recall.


*Figure 3.* Interaction effect between total screen time and immediate- and delayed recall. Those in the high screen use group did worse on both tasks.

Passive screen-use also showed significant results $F(1, 38) = 3.161$, $p < 0.01$, partial $\eta^2 = 0.08$. Figure 4 shows an interaction effect between the passive screen-use activities and the score on the logical memory tasks. Those in the high use group did worse on the delayed recall but about the same as the low use group on the immediate recall. Group main effects did not show significant results, $F < 1$. There were however significant interaction effects, $p = 0.04$.


*Figure 4.* Interaction effects between passive screen-use and scores on immediate and delayed recall tasks. Those in the high usage group did worse on the delayed recall.

Interactive screen-use showed an interaction with the logical memory score on both immediate and delayed recall. Group main effects were not significant, $F < 1$. There were however significant interaction effects, $p < 0.01$ and they can be seen on figure 5.


*Figure 5.* Interaction effect between mean scores on immediate- and delayed recall and interactive screen-use. Those in the high usage group scored lower on average.

## Discussion

This pilot study offers insight into smart-device use among young adults in Iceland. The aim was to look at the link between amount of everyday screen-use and cognitive functions. The time participants in this study said they spent on screen-based activities daily on average was 8.3 hours. This is a long time, but not so unusual for a college sample. Due to this however, it is interesting to explore effects screen-use may have on cognitive function, such as memory or attentive skills.

The main hypothesis of this study was that participants who spent more time on screen-based activities would have lower scores on Logical Memory and Stroop than those who spent less time on screen-based activities. Furthermore, the aim was to explore differences in passive- and interactive screen-based activities and whether there were differences in scores on the cognitive tasks in relation to the activity types.

The results showed that more screen-use was in all cases, except on the immediate memory recall test, linked with worse scoring on the tests. This is in tune with some of the previous research on detrimental effects of television or computer gaming (Bailey Kira et al., 2009; Patterson & Patterson, 2017; Zimmerman & Christakis, 2005). Bailey and colleagues (2009) measured activity in brain regions with an EEG while computer gamers did the Stroop task. They found that the gamers had slower proactive control than those who played computer games less or not at all. Zimmerman and Christakis (2005) looked at television watching among 6-7-year-old kids, and the links to score on reading comprehension and reading recognition scales. They found that those who had spent more time on average watching TV in the past, scored fewer points on the scales. Finally, Patterson and Patterson (2017) found a link between using laptops in college classes and lower grade scores in those classes than in classes where laptops were prohibited.

In relation to passive screen-use (e.g. watching shows or browsing social media) results of the present study also showed that more time spent on these activities linked to lower scores on the cognitive tasks. This also follows previous research on detrimental effects of watching television (Zimmerman & Christakis, 2005). Results on interactive screen-use (e.g. computer gaming, studying) showed the same negative result. Those who spent more time on the activities did worse on most of the tasks than those who spent less time on them. Previous research on computer gaming has sometimes shown that it may have some positive effects, for example in Shanchez' and colleagues study (2012) those who played a first-person shooter (FPS) game did better on post-administered visuospatial tasks than pre-administered ones. This was not the same for the participants who played a different game type in between the tasks. Those who played the FPS game also did better on tasks utilizing visuospatial skills than those who played the other

game type. In another study by Vaportzis and colleagues (2017) Tablet training for elders showed good effects on processing speed tasks. Perhaps, interactive screen-use doesn't have benefits on attention or memory but on other skills. Though it is also possible that the variables within the interactive activity group in this present study (studying and computer gaming) varied too much in how interactive they were.

When looking at the computer gaming variable alone, it showed better results, but the sample was too small to analyze it further. There were 19 participants in this sample that played any games, but some of them only spent under an hour a day on gaming so it is not ideal to explore. A bigger sample of gamers and non-gamers is needed to explore this topic, as well as more thorough questioning on which games are played.

When looking at the other interactive screen-use variable, studying more related to worse performance on the tests compared to those who studied less or not at all. The results could be because of too many hours of screen-use and the suggested bad effects, such as worse grades as in Patterson's and colleagues study (2017). Another possibility is that the activity is more passive than it suggests. Studying may involve reading or noting down things in class for example. Perhaps reading or taking notes isn't a very interactive task. How attentive students are when they study is a question difficult to measure and answer. It may depend on the field of study as well. If it is something interactive such as programming it may show a different result from other types of study. Yet another possibility is that the participants calculated the time they think they study, whereas they may in fact not be spending all the time actively studying. More research with a bigger sample and more thorough measuring of the study variable is needed to try to answer these questions.

There are noteworthy limitations in this study. Mainly, the size of the sample is small.

The homogeneity of it makes it so that it is hard to generalize the results to the public. There is also always a certain chance of skewed answers when using self-assessment measures, such as the questionnaire. The research done on cognitive skills often include clinical subjects as well as healthy ones, as with the Logical Memory test for example (Wechsler, 1945). The tests are often made to measure skills that certain clinical samples would do poorly on. Healthy individuals may not have any problems performing some parts of the task. The difference between individuals is therefore less noticeable in a healthy sample. When it comes to Stroop, many people are familiar with it, especially those studying psychology. Being too familiar with it could mean that they do better on the task than others outside the field. It is important to mention this flaw in relation to this pilot study, as the sample mainly consisted of psychology students. It was interesting to be able to see some mean- and interaction effects, but we must interpret the results with caution and keep the limitations in mind. It is also important to mention that the median split method that was used to split the screen-use variables into high and low groups is a debated method. The main reason is that this split makes it so that participants who are close to the median numbers have very similar numbers of hour usage but still land in separate groups.

It would be interesting to repeat this study with a bigger university student sample from other fields of study. It would also be interesting to test an even larger sample including groups of people of various ages, such as those who are likely to use screens less (e.g. older generations). Despite the limitations of this study, some main effects could be seen, as well as some interaction effects. There may be a difference in people's cognitive task scoring depending on amount or type of screen-use. It would be interesting to explore this further in future research.

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## APPENDIX A (informed consent form)

**Upplýst samþykki**

**Hvað felst í þátttöku:**

Þessi tiltekna rannsókn er BSc verkefni og tilgangurinn er að kanna hugræna getu í tengslum við tölvu- og snjalltækjanotkun. Tvö hugræn próf eru lögð fyrir ásamt spurningalista.

**Réttur til að hafna og hætta þátttöku:**

Þátttakandi hefur alltaf möguleika á að hætta við þátttöku á hvaða stigi sem er án útskýringa. Einnig má hann/hún sleppa því að svara einstökum spurningum af hvaða ástæðu sem er. Ef þátttakandi vill sleppa spurningum í spurningalistanum þarf að láta rannsakanda vita þar sem tölvan gefur upp villu ef eitthvað er ósvarað.

**Framkvæmd rannsóknar**

Fyrst er Logical Memory lagt fyrir. Rannsakandi les stutta sögu og spyr svo út í hana. Næst er STROOP lagt fyrir og síðan er spurningalisti útfylltur af þátttakanda. Eftir spurningalistann er aftur stuttlega spurt út í söguna sem lesin var í byrjun.

Ekki verður hægt að rekja svör til einstakra þátttakanda þar sem hver þátttakandi dregur sér handahófskennda tölu í upphafi sem notuð er í stað nafn hans við úrvinnslu gagnanna. Nöfn þátttakanda koma aldrei fram í skýrsluskrifum eða kynningu á verkefninu.

*Tilgangur þessarar rannsóknar hefur verið kynntur fyrir mér og í hverju þátttaka mín er fólgin. Ég er samþykk(ur) þátttöku.* ☐

| | | |
|---|---|---|
| Undirskrift Þátttakanda | Dagsetning | Undirskrift rannsakanda |

# APPENDIX A (Researcher's form)

Researcher's For **Númer þátttakanda:** _____

**Leshraði** : _____

**Stroop glærupakkanúmer**: _____

**Athugasemdir** (lesblinda/Litblinda etc): _____

**Glæra 1**

| Villur: | Næstum Villur: | Tími: |
|---|---|---|
| _____ | _____ | _____ |

**Glæra 2**

| Villur: | Næstum Villur: | Tími: |
|---|---|---|
| _____ | _____ | _____ |

**Glæra 3**

| Villur: | Næstum Villur: | Tími: |
|---|---|---|
| _____ | _____ | _____ |

**Glæra 4**

| Villur: | Næstum Villur: | Tími: |
|---|---|---|
| _____ | _____ | _____ |

**Logical Memory athugasemdir?**

_____

_____

_____

# APPENDIX B (Stroop)

Á næstu glærum átt þú að segja litinn á hverju orði fyrir sig. Eins og áðan ferðu línu fyrir línu eins og þú sért að lesa bók. Gættu þess að lesa samt ekki orðin heldur aðeins segja litinn.

Þegar þú ert tilbúin/n máttu fletta á næstu glæru og byrja. ☺

Prufa:

Grænn Gulur Brúnn Bleikur

## APPENDIX B (Stroop)

| | | | |
|---|---|---|---|
| Gulur | Grænn | Brúnn | Svartur |
| Rauður | Brúnn | Blár | Grænn |
| Brúnn | Gulur | Grænn | Bleikur |
| Blár | Grænn | Gulur | Brúnn |
| Bleikur | Rauður | Brúnn | Svartur |
| Rauður | Bleikur | Blár | Brúnn |
| Grænn | Svartur | Brúnn | Gulur |
| Gulur | Grænn | Svartur | Bleikur |

| | | | |
|---|---|---|---|
| Gulur | Grænn | Brúnn | Svartur |
| Rauður | Brúnn | Blár | Grænn |
| Brúnn | Gulur | Grænn | Bleikur |
| Blár | Grænn | Gulur | Brúnn |
| Bleikur | Rauður | Brúnn | Svartur |
| Rauður | Bleikur | Blár | Brúnn |
| Grænn | Svartur | Brúnn | Gulur |
| Gulur | Grænn | Svartur | Bleikur |

# APPENDIX B (Stroop)

| | | | |
|---|---|---|---|
| Gulur | Grænn | Brúnn | Svartur |
| Rauður | Brúnn | Blár | Grænn |
| Brúnn | Gulur | Grænn | Bleikur |
| Blár | Grænn | Gulur | Brúnn |
| Bleikur | Rauður | Brúnn | Svartur |
| Rauður | Bleikur | Blár | Brúnn |
| Grænn | Svartur | Brúnn | Gulur |
| Gulur | Grænn | Svartur | Bleikur |

| | | | |
|---|---|---|---|
| Gulur | Grænn | Brúnn | Svartur |
| Rauður | Brúnn | Blár | Grænn |
| Brúnn | Gulur | Grænn | Bleikur |
| Blár | Grænn | Gulur | Brúnn |
| Bleikur | Rauður | Brúnn | Svartur |
| Rauður | Bleikur | Blár | Brúnn |
| Grænn | Svartur | Brúnn | Gulur |
| Gulur | Grænn | Svartur | Bleikur |

## APPENDIX C (Logical Memory Story)

| **Saga B** | **Atriði** | **Þema** |
|---|---|---|
| Klukkan 6 / á mánudags/ kvöldi, / var Jón / Sveinsson / frá Akureyri / | _____ | _____ |
| að horfa á sjónvarpið / um leið og hann klæddi sig / til að fara út. / | _____ | _____ |
| Stormviðvörun / truflaði sjónvarpsútsendinguna / | _____ | _____ |
| til að vara við vonskuveðri / sem væri á leið inn á svæðið / | _____ | _____ |
| eftir tvær til þrjár klukkustundir / og myndi standa yfir til morguns. / | _____ | _____ |
| Þulurinn sagði / að stormurinn bæri með sér haglél / og 10 mm / úrkomu / | _____ | _____ |
| auk þess sem hitastigið myndi lækka / um 5 gráður. / | _____ | _____ |
| Jón ákvað að vera heima. / | _____ | _____ |
| Hann fór úr jakkanum sínum / og settist niður / | | |
| til að horfa á gamlar kvikmyndir. | _____ | _____ |
| | **Atriði** (0-25 stig) | **Þema** (0-8 stig) |
| _____ _____ | | |

**APPENDIX C (Logical Memory scoring)**

*Viðmið* **Logical Memory I og II**

| | Einkunn 0 eða 1 | | |
|---|---|---|---|
| Saga B | Sögu-eining | Efnis-bútur | Viðmið við einkunnagjöf |
| Klukkan 6 á | | | *Kl. 6* verður að koma fram |
| Mánudags- | | | *Mánudagur* verður að koma fram |
| Kvöldi, | | | Kvöld í einhverju samhengi |
| Var Jón | | | Jón eða afbrigði af nafninu |
| Sveinsson | | | Sveinsson verður að koma fram |
| Frá Akureyri | | | Akureyri verður að koma fram |
| | | | Vísb. Um aðalpers. Sem er karlmaður |
| Að horfa á sjónvarpið | | | Vísb. Um að hann hafi verið að horfa/hlusta á sjónvarpið |
| Um leið og hann klæddi sig | | | Vísb. Um að hann hafi klætt sig |
| Til að fara út | | | Vísb. Um að hann hafi verið að fara út |
| | | | Vísb. Um að sögupersóna hafi verið að taka sig til/fara út |
| Veðurskeyti | | | Vísb. Um að það hafi komið tilkynning um veðrið |
| Truflaði sjónvarpsútsendinguna | | | Vísb. Um að dagskráin hafi verið rofin |
| | | | Vísb. Um veðurskeyti |
| Til að vara við voðaveðri | | | Vísb. Um viðvörun við slæmu veðri/stormi |
| Sem væri á leiðinni á svæðið | | | Vísb. Um að stormur væri á leiðinni |
| | | | Vísb. Um að stormurinn væri á leiðinni inn á svæðið |
| Innan 2-3 klukkustunda | | | Setning sem merkir 2-3 klst. |
| Og myndi standa yfir til morguns. | | | Vísb. Um að stormurinn myndi verða þar til næsta dag |
| | | | Vísb. Um tímalengd stormsins |
| Þulurinn sagði | | | Vísb. Um að einhver hafi tilkynnt um storm |
| Að stormurinn bæri með sér haglél | | | Vísb. Um að það gæti komið haglél |
| Og 10 mm | | | *10. mm*. Verður að koma fram |
| úrkomu | | | *Úrkoma*/rigning þarf að koma fram |
| Auk þess sem hitastigið myndi lækka | | | Vísb. Um að hitastig myndi lækka |
| Um 5 gráður. | | | *5 gráður* eða samsvarandi verður að koma fram |
| | | | Vísb. Um virkni stormsins |
| Jón ákvað að vera heima. | | | Vísb. Að hann hafi ákveðið að vera heima |
| | | | Vísb. Um að sögupers. hafi ákv. að vera heima |
| Hann fór úr jakkanum sínum | | | Vísb. Um að hann hafi farið úr yfirhöfn |
| Og settist niður | | | Vísb. Um að hann hafi sest niður |
| Til að horfa á gamlar myndir. | | | Vísb. Um að hann hafi horft á kvikmyndir |
| | | | Vísb. Um að sögupers. Hafi ákveðið að horfa á kvikmyndir eða sjónvarp |

**Sögueining (Story Unit)** **Efnisbútur (Thematic Unit)**

**APPENDIX D (Questionnaire)**

## Tölvu- og snjalltækjanotkun

1. Hvað er Þátttakendanúmerið þitt?

* 2. Hvert er kyn þitt

* 3. Hver er aldur þinn

---

4. Finnst þér oft erfitt að fylgjast með í tímum?

- ○ Já
- ○ Nei
- ○ Ég er ekki í námi

* 5. Merktu við öll eftirfarandi tölvu og/eða snjalltæki sem þú hefur greiðan aðgang að og notar reglulega

- ☐ Borðtölva
- ☐ Laptop
- ☐ Ipad
- ☐ Snjallsími
- ☐ Leikjatölva (t.d. playstation, xbox, gameboy)
- ☐ Annað (vinsamlegast tilgreindu hvað)

# Appendix D (Questionnaire)

6. Hver er meðaleinkunn þín í náminu?

- ◯ Undir 5
- ◯ 5-6
- ◯ 7-8
- ◯ 8,5+
- ◯ Ég er ekki námsmaður

* 7. Í hvað notar þú snjalltækið og/eða tölvurnar allra helst?

- ◯ Samfélagsmiðla (t.d. facebook, twitter, instagram, snapchat)
- ◯ Tölvuleikjaspilun
- ◯ Lærdóm
- ◯ Blómynda- og Þáttaáhorf
- ◯ Annað (vinsamlegast tilgreindu hvað)

* 8. Hvað notar þú tölvu/snjalltæki mikið að meðaltali á hverjum degi?

- ◯ Undir klukkustund
- ◯ 1-2 Klst
- ◯ 3-4 klst
- ◯ 5-6 klst
- ◯ Meira en 6 klst

* 9. Tilgreindu hversu mikinn tíma þú notar að meðaltali daglega í hverja athöfn fyrir sig (t.d. 0 klst, 2 klst, 8 klst)

| | |
|---|---|
| Samfélagsmiðlar | |
| Tölvuleikjaspil | |
| Lærdómur | |
| Blómynda- og þáttaáhorf | |
| Annað | |

## Appendix D (Questionnaire)