Evaluating the Effects of Mobile Computer Systems on the Mental Health of Individuals

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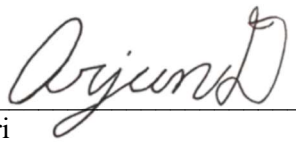
On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Signature  _____ Date_____4/27/2021_____
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Preface

Our world, as well as its human inhabitants, is increasingly becoming reliant on computing. Computing, once only accessible to us at arcade centers, office buildings, and university laboratories is now progressively spending more time directly in front of our faces and is seen by some as a coming replacement for social interactions. As our society, especially the younger generation, spends more and more time on mobile computers, one must address the growing controversy surrounding these devices and societal wellness. In addition, the COVID-19 pandemic has placed our society deeper into the trance with mobile devices. This thesis seeks to address this controversy by performing an end-to-end evaluation and analysis on the effects of mobile computing on our mental health up to and including the COVID-19 pandemic by analyzing literature and conducting a research survey on young adults' mental health during quarantine.

This research problem slightly deviates from that in the prospectus in that it broadens the scope of STS research to study not just mobile games but mobile computers in general. This change was implemented due to my recent perception of the COVID-19 pandemic on the mental health of University of Virginia students.

In this research paper, a comprehensive analysis of the literature on mobile phones and mobile game usage with respect to mental health was done. In addition, a research survey was performed on 13 young adults who were queried on their use of mobile devices and mental health during the COVID-19 pandemic. The results indicate that there is not enough literature to provide evidence of mental health declines in mobile video gamers. However, there is enough to make more of this indictment on social media and internet usage in smartphones. The experimental results indicate that some individuals are at a greater risk for mobile electronic

abuse than others. It is recommended that engineers working on developing mobile computers should be wary of the effects of social media and internet usage on mental health and should seek to develop mental health apps on these platforms which can be used by mental health patients.

I would like to specially thank Nick Moon, Patrick Thomas, and Daniel Mizrahi for assisting me on my technical capstone research. Furthermore, I would like to thank Dr. Harry Powell for providing necessary instruction and aid in the completion of the capstone project. Also deserving of gratitude are Dr. Richard Jacques, Dr. Bradford Campbell, Dr. Ron Williams, and Dr. Yuan Tian for building my passion for ethical engineering in software and computer systems engineering.

Literature Review

There has been no shortage of literature written in the last decades concerning the effects of mobile electronic devices such as smartphones and tablets on the mental health of individuals such as studies by Abi-Jaoude et al., (2020) or Amidtaher et al., (n.d.). Likewise, there have been near equally numerous literatures over the past couple decades concerning the effects of video games on mental health of individuals. In contrast, there have been, relatively, only a limited number of studies on the use of mobile gaming consoles (such as the Nintendo 3DS or Nintendo Gameboy) as well as a limited number of studies on the usages of portable/mobile computers in general on mental health during the COVID-19 pandemic. I have not been able to identify any similar studies to date on the overall use of mobile computing and mental health.

The most comprehensive review of literature concerning the topic of cell phones and mental health comes from De-Sola Gutierrez et al. (2016). In this literature review, the authors

point out that the aggregate of literature on this topic shows that cell phone addiction is most frequent among young adults, females, and individuals with higher socioeconomic status. This study is comprehensive; however, it was completed in 2016 and therefore cannot account for mobile technology use and trends since then. For example, the number of U.S youth who receive a cell phone today is up 20% since 2016 ("How Do Smartphones Impact Youth Mental Health?," n.d.). One of the most notable studies on mobile game addiction was done by Wang et al. (2019) which is discussed in detail later in this paper. There have been no literature reviews, however, which discuss the positive and negative impacts of mobile games on mental health.

Due to the relatively small amount of time between the start of the COVID-19 pandemic and this thesis's writing, there have not been any studies on the usage of mobile devices as it relates to mental health during the pandemic. However, there have been copious studies on the role of social media in societal mental health during the pandemic. According to one study by Gao et al. (2020) who studied the association between social media exposure and mental health in Wuhan, China during COVID-19, "there are high prevalence of mental health problems, which positively associated with frequently SME during the COVID-19 outbreak". This research will be done with respect to the social construction of technology framework. This research hopes to provide recommendations on how better engineers can develop low-power mobile computer systems with appreciation for societal mental health.

Methodology

The research for this paper consists of two parts. The first part was a comprehensive study of literature and published studies pertaining to the research problem. This section will address the association between mobile computing and mental health over the past couple

decades up until the COVID-19 pandemic. The services of Google Scholar were employed for this section. The second part involved surveying X university students on their experiences with the use of mobile electronic devices before and during the COVID-19 pandemic. This experimental research hopes to address the questions on how mobile electronic use affected the mental health of individuals during the COVID-19 pandemic. As stated in the previous section, there were zero studies done, specifically, on the effects of mobile electronics on mental health between this thesis's writing and the start of the pandemic. Therefore, I considered experimental research to be the best way to gain insight into the aforementioned research question. The survey given to each individual in the study can be found in the Appendix.

Smartphones and Mental Health

As briefly mentioned in the preface, the conversation around cell phones and mental health has grown considerably in the last decade to the increased use of such devices. The percentage of adults in the United States who claimed to own a cellphone increase from 62% to 96% over the last 20 years. Smartphones, in particular, were much faster growing than their predecessors in the mobile computing world due to their versatility in being able to make calls, upload/download information to/from the internet, and support better video game development. The penetration of smartphones, alone, in the U.S. has grown from 35% to 81% in just the last 10 years ("Demographics of Mobile Device Ownership and Adoption in the United States," n.d.). The number of smartphones sold per year worldwide rose from just 122 million units per year in 2007 to 1.535 billion units per year in 2020 ("Cell phone sales worldwide 2007-2021," n.d.).

In parallel to this meteoric rise in unprecedented connectivity at the fingertips of smartphone users was an equally meteoric decline in the overall mental health of individuals.

The percentage of U.S. young adults (age 18-25) who reported experiencing psychological distress in the previous month jumped by 71% from 2008 to 2017. Rates of serious psychological distress increased by around 70% in adults age 20-21 across the same time frame. This trend continued despite a drop in the unemployment rate and stability in alcohol which suggests, unfortunately, that technology is the primary instigator ("Mental Health Issues On the Rise Among Adolescents, Young Adults," n.d.). To clarify this hypothesis, we review some of the biggest studies in the literature pertaining to this problem.

One of the most comprehensive studies done in the last decade concerning this problem was done by Babadi-Akashe MSc et al. (2014). This study involved observing the effects of mobile phones on university students studying in Iranian universities. From a target population, 296 students were randomly selected to undergo a mental health survey on their current mental health and cell phone usage. The results of the study indicated an "inverse relationship between mobile phone addiction and mental health." Students placed in the habitual personality category had the worst average mental health of all categories. The authors define habitual behavior as "behaviors that are formed from habit, without hesitation, thought, and mental awareness in order to achieve a particular purpose." The authors further speculate that students placed in the habitual category use mobile phones as an escape from stress, anxiety, or depressing circumstances they find themselves in such as assignment deadlines. This leads one to contemplate that cell phone use is a results of mental health decline and state rather than the source. That is, the usage of mobile phones is a symptom of lower mental health of some personality groups rather than the source.

However, more recent studies focus directly on determining correlations between levels of mobile device use and mental health parameters. This includes one by Thomée (2018) which

studied the effects of mobile phones on depressive symptoms and lower sleep quality. Some relevant results from this study include that mobile phone use is negatively correlated with sleep quality and mental well-being in adolescents. Another study by Alexis Blue (2019) at the University of Arizona surveyed a 346 young adults age 18-20 and suggested that "smartphone dependency predicts higher reports of depressive symptoms and loneliness, rather than the other way around" meaning that the technology takes an active role in suppressing mental health.

According to Babadi-Akashe et al. (2014), some personality groups are more prone to cell phone addiction than others. The two more-recent studies appear to show that smartphone use does correlate with mental health problems. So, what exactly in smartphones makes them addicting? In the next section, one common type of software found of smartphones, video games, is analyzed in the context of the question.

Mobile Video Games and Mental Health

One of the only studies published in the last decade on the role of mobile gaming on mental health has been published by J. Wang et al. (2019). The study was a direct observational study on mobile gaming and depression, social anxiety, and loneliness. This research was performed on 600 junior high school students in Guizhou province in China. Each student was measured for mobile game usage and addiction and several mental health parameters (social anxiety, depression, and loneliness.) The study concluded that "Mobile addiction was positively correlated with depression, loneliness, and social anxiety, with the correlations ranging from 0.18 to 0.46". This study does indicate that mobile game addiction is highly correlated with several unwanted symptoms of low mental health such as depression. However, the study does not indicate that mobile game use in modest quantities results in any of these negative mental health

outcomes.

Addiction to any dopamine-inducing external stimulus does not necessarily mean that said stimulus is harmful at all when exposure is limited. For example, it is fallacious to claim that a relationship between alcohol addiction and declined mental and social health implies that moderated consumption of alcohol leads to the same decline. Sometimes, it is quite the contrary. While there are only a few studies on the dangers of mobile gaming with respect to mental health, there have been numerous ones on the positive effects of mobile gaming.

Some, in particular, focus on smartphone mental health "apps", a growing class of "downloadable" software for smartphones. Given the limited number of psychiatrists and mental health care facilities in an area, these apps can provide a faster and less-confrontational way to alleviate symptoms of mental health disorders such as depressive/suicidal thoughts and panic attacks according to a study by Chandrashekar (2018). This study also found that the mental health apps studied reduced symptoms of depression and anxiety in patients when compared to controls. The user reviews of apps to alleviate schizophrenia symptoms had a positive review rate from users according to the same study. Chandrashekar then speculates that the most effective of mental health apps are ones which contain a simple user interface, transdiagnostic capabilities, self-monitoring features, and high-patient engagement (such as through game-like interactions). However, researchers are still overall unsure of the efficacy of these apps. Two systematic literature reviews on the efficacy of mental health apps, Grist et al. (2017), K. Wang et al. (2018), and Payne et al. (2015), determined that more robust research on a larger population, more mental health apps, and better metrics to measure efficacy are needed.

It is clear that, while the emerging field of smartphone applications for mental health symptom alleviation requires more research to determine its efficacy today, it certainly has a

great amount of potential to deal with mental health problems faced by individuals. As mentioned before according to Chandrashekar (2018), the mental health apps with "high-patient engagement" such as via "gamified interactions" are the most effective due to providing an incentive for the individual to use the app. This provides a promising future for smartphones with respect to mental health. That said, there are numerous studies which point to the positive effects of video game-playing in general (Jones et al., 2014; Halbrook et al., 2019; Primack et al., 2012). Positive effects of playing video games as claimed by these studies come from those which involve physical movement and psychological therapy. However, additional studies note declines in mental health via video game addiction (Wittek et al., 2015; Krossbakken et al., 2018). It is therefore, concluded, from this section that moderated video game usage is not substantially correlated with mental health decline.

Mobile Electronics, Mental Health, and the COVID-19 pandemic

While there are numerous studies concerning the effect of mobile electronics on mental health, there are zero such studies on the use of mobile electronics and mental health during the COVID-19 pandemic. It is hypothesized that any effects that mobile electronics have on the mental health of their users would be amplified during the quarantine periods in the midst of the pandemic. To get a better insight on this problem, surveys were sent out to 21 young adults (age 18-24) in Spring 2021. The surveys contained queries referring to the participants' experiences with mobile electronics and mental health over the course of quarantine period during the pandemic. Specifically, each survey consisted of 14 questions which can be more viewed in the appendix. All participants were explicitly advised that they would not be expected to answer any questions they were uncomfortable in answering. Out of the 21 potential participants, 12

participants returned the surveys with all questions answered. All of the participants who answered the surveys identified as male. Ten participants identified as students, two identified as employees, and one identified as neither an employee nor a student. The first two questions queried the participant on his/her mental health before and during quarantine. The participants were asked to give an answer on a scale of 1-10 with a 10 corresponding to an extremely negative state of mental health. The responses can be better visualized in Figure 1.

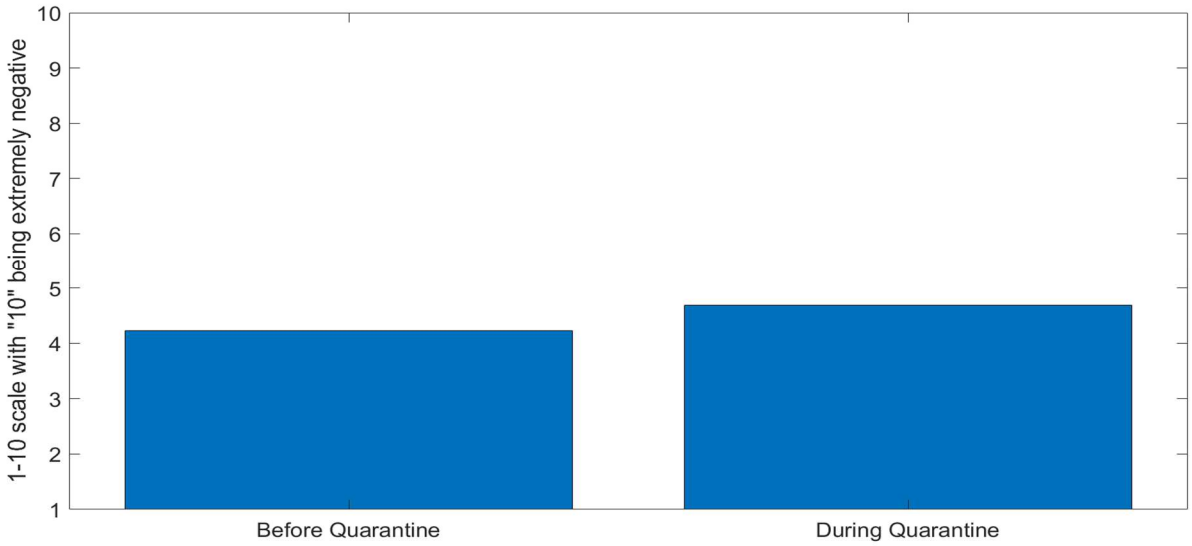

Figure 1: Comparison of average participant mental health before and during COVID-19 quarantining.

As one can note from the plot, the average mental health score of individuals mid-quarantine was slightly higher (worse) than in the pre-quarantine period. This can suggest that the lifestyle of quarantining during the pandemic contributed to mental health decline in young adults. The sparse studies on mental health during the pandemic do generally agree with this claim (Y. Wang et al., 2021; Henssler et al., 2020). However, this average mental health score difference does not necessarily come from mobile electronics. Figure 2 illustrates the responses of the participants to queries regarding their usage of mobile electronic devices before and during quarantine.

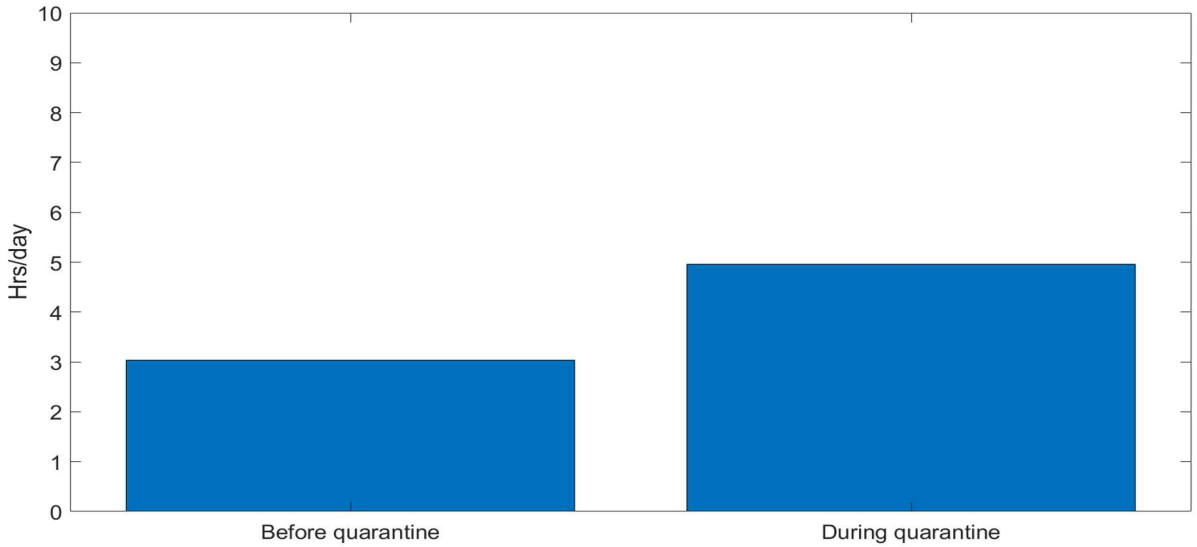

Figure 2: Comparison of average participant mobile device use before and during COVID-19 quarantining.

As one can note, the use of average mobile device use (in terms of hours/day) significantly increased from ~3 hours/day to ~5 hours/day. The responses of the participants on how much they think their change in mobile device usage during quarantine caused a change in their mental health during the same period can be expressed in Figure 3.

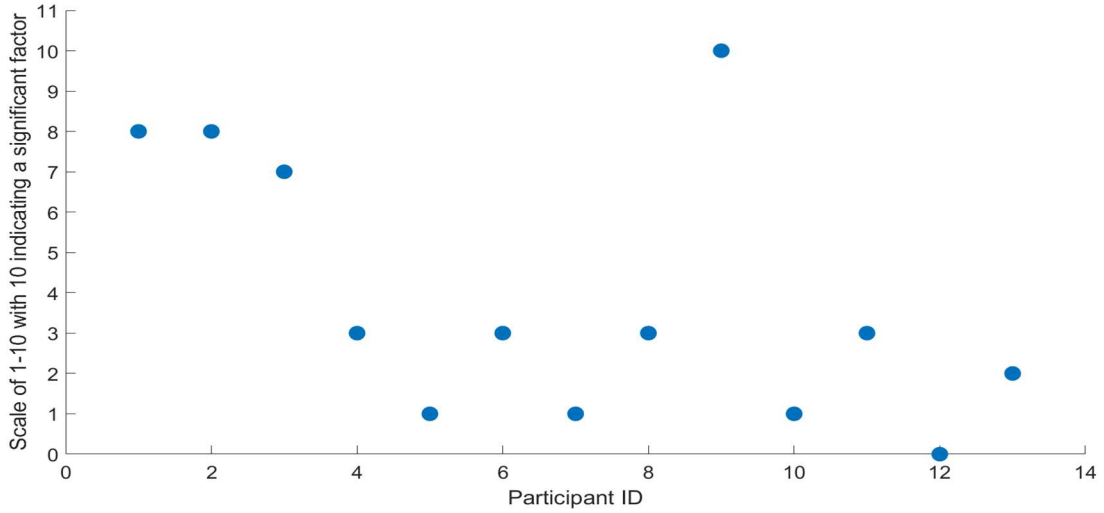

Figure 3: Participants' responses when asked how much a factor their change in mobile device usage resulted in their change in mental health during quarantine.

One should note that these responses are incredibly scattered with respect to the y-axis.

Four participants responded with a response at least 7 to this query suggesting that they believe their mobile electronic device was a significant factor in their mental health change. However, nine participants responded with less than a 5. This does support the study by Babadi-Akashe et al. (2014) which claimed that individuals with different personality profiles had differing changes in mental health when exposed to mobile electronics and free time. In other words, some personality groups are more at risk for cell phone addiction and mental health decline. When asked why how relevant the sentence "mobile devices provide me an escape from sad, stressful, or depressing thoughts" is to one's use of mobile devices during quarantine, the responses were scattered as well as can be visualized in Figure 4.

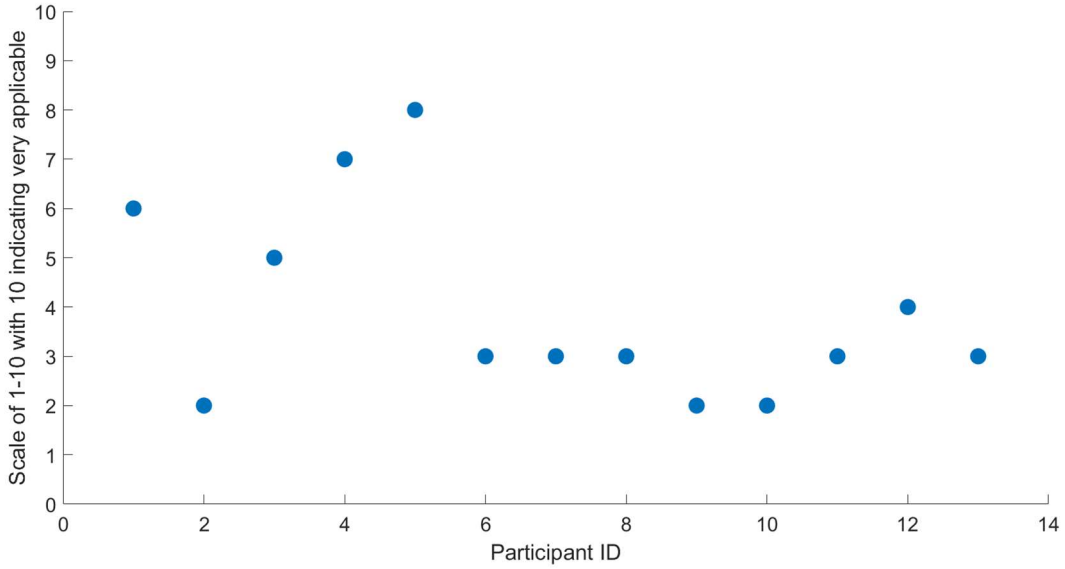

Figure 4: Responses of participants to how applicable question #6 is to their use of mobile devices during quarantine.

This, again, supports the previous suggestion that different personality groups experience using their mobile device differently. Participants that answered the aforementioned question with a higher number on the scale might be more likely to turn to their mobile devices as a means of escape from external stimuli which cause stress, sadness, or anxiety. Others are more immune to this type of usage.

The limitations of this study are now discussed. The very small sample size (n = 13) is one of the most obvious. Another is that 13 out of 13 participants were young adult men. The responses to the questions could be radically different from females or non-binary individuals De-Sola Gutierrez et al. (2016). The responses could also be radically different across age groups ("How Do Smartphones Impact Youth Mental Health?" n.d.).

Conclusion

Overall, the role of mobile computers concerning mental health is a highly nuanced one. From the first section of the body, we conclude that smartphones, specifically, do lead to mental health decline, especially in adolescents. However, some personality groups are more prone to cell phone abuse than others. The experimental research results discussed in the third section showed that, while participants increased their mobile electronic use during the pandemic, they greatly differed in their responses on whether they see mobile phones as hedonistic escapes from bad thoughts or even as a source of the problem. This suggests, like the first section of the body, that some personality groups tend to be more susceptible to the lure of mobile devices than others. In terms of mobile gaming and mental health, there is currently too few existing studies to determine a positive correlation between mobile gaming and lower mental health. Other studies reviewed in the second section of the body point to potential beneficial uses of mobile games in smartphone apps for alleviating symptoms of mental health disorders. However, there is inconclusive evidence concerning the efficacy of the state-of-the-art mental health apps. All in all, more extensive research should be done on determining if mobile game usage correlates with mental health decline. It is speculated, thus, that the "addictiveness" of smartphones does not come from video games but rather from social media and internet usage. The social construction

of technology theory states that future engineers should drive technology. I believe in amending this statement to “future engineers should drive ethical technology.” It is therefore, recommended by this thesis that more research be done on ways to limit the effects of social media on users of smartphones and other network-compatible mobile devices since this seems to be the primary cause of the negative relationship between mental health and mobile phone usage. It is also recommended that more development be done on creating mental health apps and games on mobile computer systems to usher in a new age of faster, more effective mental health solutions via technology.

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APPENDIX

Survey questions for COVID-19 and mental health research participants:

1. How would you rate your mental health before the COVID-19 pandemic (on a scale of 1-10 with 10 being “extremely negative”)?
2. How would you rate your mental health while quarantining during the COVID-19 pandemic (on a scale of 1-10 with 10 being “extremely negative”)?
3. How many hours a day, on average, did you use your cell phone or other mobile electronic device before the COVID-19 pandemic?
4. How many hours a day, on average, did you use your cell phone or other mobile electronic device while quarantining during the COVID-19 pandemic?
5. Do you think your change in mental health from question 1 and 2 was caused by a change in your cell phone usage from question 3 and 4 (On a scale of 1-10 with 1 being "not at all" and 10 being “a very large amount”)?
6. How much does the following statement apply to you and your use of mobile electronics (on a scale of 1-10 with 10 being very applicable): "Mobile electronic devices offer me and my mind an escape from stressful, sad, or negative thoughts."