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How Much Does Multitasking Cost You? An Investigation of the Effect of Various Types of Multitasking on Cognitive Functioning Through Reaction Time Measures

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Multitasking is a widely studied phenomenon that has garnered interest in recent years due to the development of modern technology. The act of performing numerous tasks that requires a split in cognitive function has always existed, but it has become increasingly prevalent because of the commonality of texting while driving and the dangers associated with it. Due to the perceived risks of multitasking while operating machinery, laws have been implemented to prevent it in many states, but outside the high stakes circumstance of texting and driving, not much exploration has been done into the efficacy of task juggling in a low risk setting to evaluate the costs and benefits. Previous methods of testing the effects of multitasking have largely been within the context of driving and academic performance and have concluded that engaging in multiple activities affects cognitive functioning. However, there has been less focus on a quantifiable and objective measure to the impact of distractions in a home setting. The aim of this study is to use the Brain Gauge, a cognitive assessment tool, to investigate the relationship between the intensity and type of multitasking activities and cognitive processing through the inclusion of different media types to serve as distractors. This was explored by testing the reaction times of individuals while they simultaneously performed a series of engaging but mundane tasks. Ultimately it was found that there was a statistically significant change in reaction time while watching television compared to the control. The results from this study can be used to better understand how multitasking affects cognitive function and help to determine whether it should be avoided during crucial tasks such as homework and driving.

Introduction/ Background

Multitasking is the attempted execution of more than one simultaneous task, leading to an overlap of cognitive processes required to perform each task. It is a behavior that has become more prevalent in recent years due to an increase in dependence upon accessible technology. Particularly among college-aged individuals, mobile devices are often used in conjunction with everyday tasks such as driving, eating, walking, and academic work such as listening to lectures and doing homework. The topic of multitasking has attracted considerable interest in regard to driving because some argue that it increases the chances of road accidents and poses a public health threat. In some studies, conversely, instances of multitasking have been found to be beneficial while driving [1]. Regardless, a survey of over 4,000 college-age students (with the mean age being 21) found that 91% of them admit to multitasking with their cellular devices while driving [2].

Generally, multitasking has been linked with the decreased cognitive performance of the brain over time [3]. Investigations have found that children who have a high tendency to multitask using technology often had worse functional connectivity in the dorsal striatum of their brains. The relationship between multitasking and a decrease in brain health over time is clear, though the direct effects on brain function while actively multitasking are still being debated. Few studies have used sensory technology to test how the intensity of a multitasking distractor relates to changes in cognitive function. Understanding the mechanisms behind the decrease in performance due to a division of attention is significant within a modern context where the attachment to handheld devices has made multitasking commonplace. Several studies have examined the risks of multitasking while driving in recent years. The results of those studies indicate that reaction times dropped significantly when an event occurred in a subject’s periphery while driving, which underlines the level of impairment associated with multiple points of focus [4].

The Brain Gauge, pictured in Figure 1, is a novel tool used for assessing brain health. With a dual-site stimulator that is able to deliver precise sinusoidal stimuli to two fingertips, numerous tasks can be administered to individuals in order to construct a profile for their central nervous system (CNS) [5]. For the purposes of this study, the Brain Gauge will be used to study reaction time. As shown in Figure 2, a stimulus will be applied to one of the two sites, prompting the user to press down with their index finger at the other of the two sites. A short waiting period exists between each of the following stimuli.

Few studies have utilized novel techniques, such as the Brain Gauge, to directly measure reaction time due to an applied stimulus against media multitasking. In 2014, researchers used an Audio Visual Reaction Time Machine to determine the effects of multitasking on reaction time in women compared to men [6]. While tests like these compare the reaction time from visual and auditory stimuli to multitasking, this study seeks to compare physical stimuli to multitasking. This study aims to investigate how the intensity of the unimportant task can affect an individual ability to respond to an important task.

Methods

The study was conducted with 42 healthy individuals with a mean age of 21.4 ± .76 years. The test was designed to determine how the intensity of a distraction relates to a change in reaction time. The nature and type of the test was described to the subjects and their consent was obtained for the test. The instrument used to conduct the test was the Cortical Metrics Brain Gauge Home. As a control, the participants were first asked to take the reaction time test with no distractions. The test is performed by applying a stimulus to one of the buttons on the brain gauge, as seen in Figure 1. The participant is asked to click the other button as soon as they feel the stimulus. A diagram of this test can be found in Figure 2. This test is repeated 20 times and the time it takes for the participant response is recorded and averaged. For the first experiment, the distraction was provided by incentivizing participants to watch around 2 minutes of a tv show or video of their choice. They were informed to ensure that they were watching a video that they enjoyed or were engaged in. After the participant was engaged with the show for 2 minutes, they were asked to continue watching and retake the 20 trial reaction time test. For the next experiment, the subjects were told to listen to a playlist or an album that they enjoy or would be engaged in. After 2 minutes, they were informed to repeat the same reaction time test. Finally, the subjects were instructed to listen to a podcast of their choice for 2 minutes. The reaction time tests were analyzed using Microsoft Excel software.

Figure 1. *Brain Gauge. From Tommerdahl et al. (2019)*

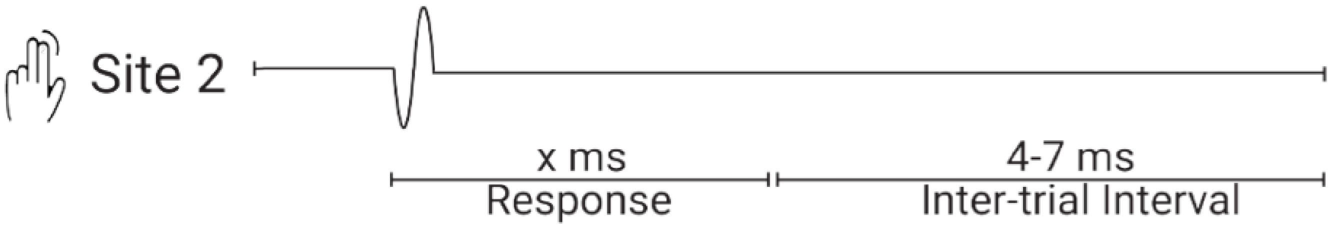

Figure 2. *Reaction time test diagram. From Tommerdahl et al. (2019)*

Limitations

The reaction time varies from person to person due to numerous factors such as sleep level, emotional state, and caffeine intake. In an attempt to account for this, the results analyzed the differences between reaction time and reaction time variability for each subject independently rather than between subjects. Additionally, the level of engagement each participant experiences with the distractors is highly variable, so the variability in reaction time between stimuli was used to qualify levels of distraction.

Results

The results of the study found that the average reaction time for the participants significantly increased with the T.V. distraction. As shown in figure 3, each of the 3 distractor tasks correlated with a percent increase in reaction time average, but only the T.V. distraction was found to be statistically significant.

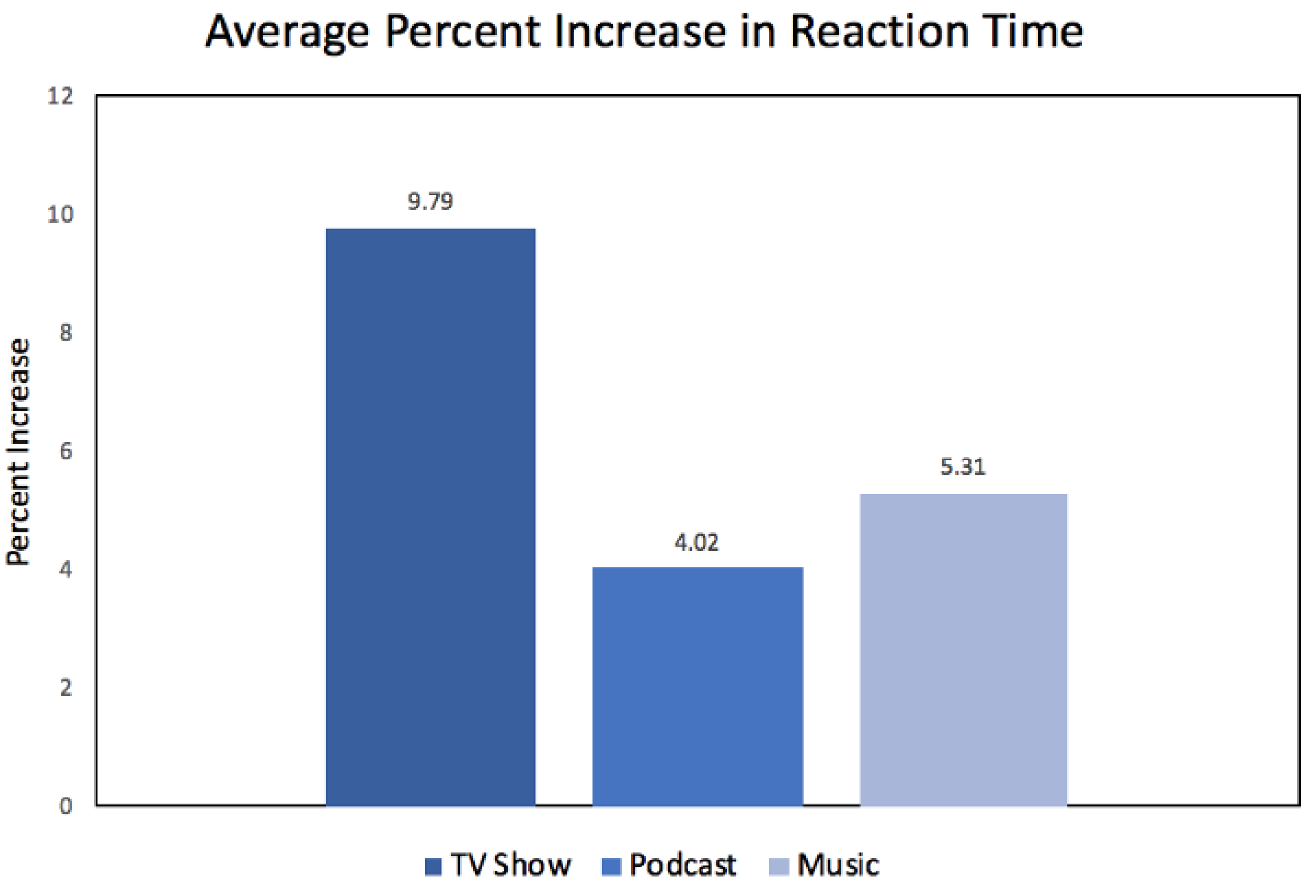

Figure 3. *Bar graph comparing reaction time with each distraction*

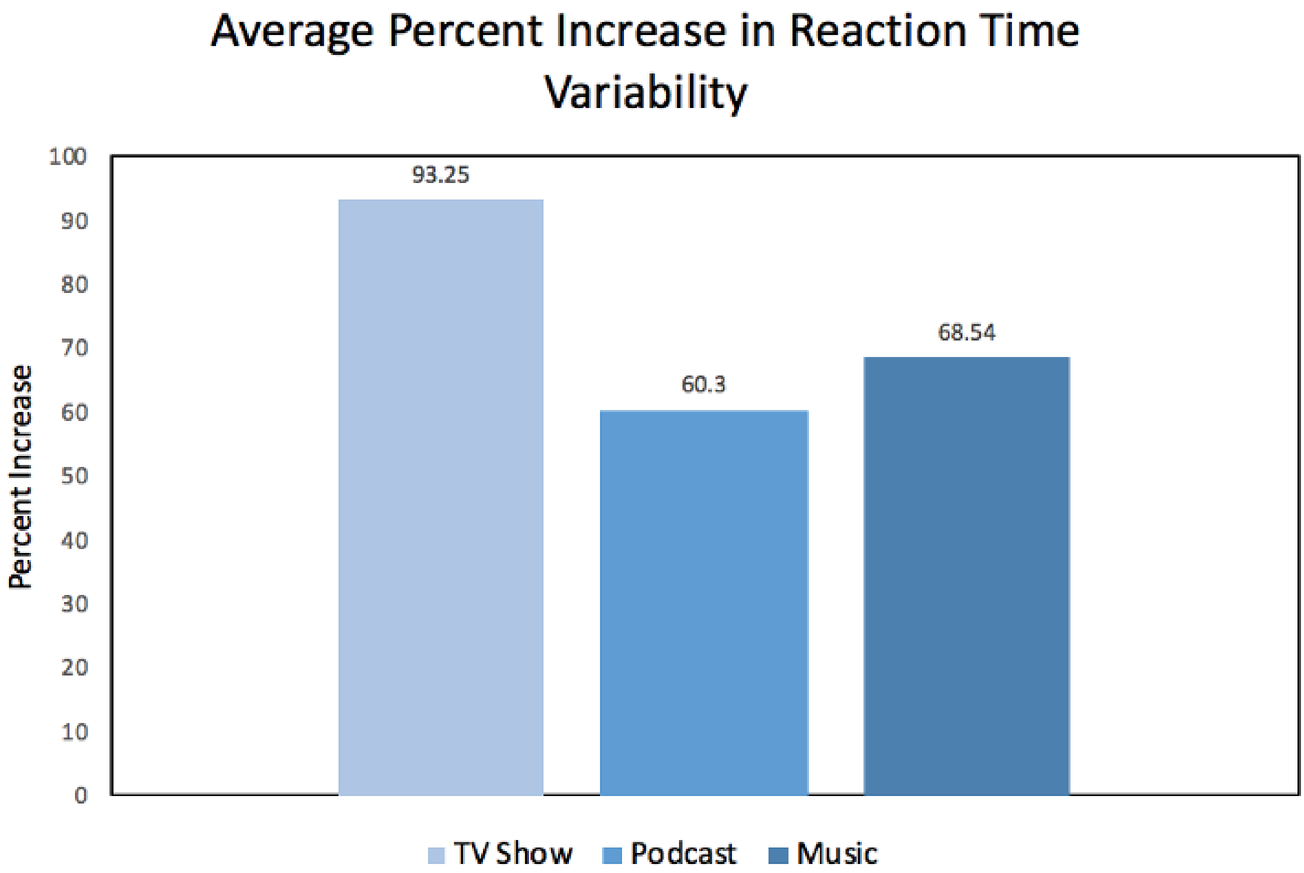

Figure 4. *Bar graph comparing reaction time variability with each distraction*

The data from each of the subjects was compiled into excel for analysis. The values collected from any participant who failed to complete the full test battery (e.g. did not complete one of the trials as instructed) were omitted. In order to compare the results as a group, the percent difference seen between the trials for each individual participant was recorded and the percent differences of the entire subject populations were then compared. The average percent difference for reaction time between each of the trials and the control is illustrated in ***Figure 3***. The largest observed difference in reaction time relative to the control was found to be in the first trial (television) with a mean percent difference of 9.79%. The average percent difference between reaction time variances can be seen in ***Figure 4***. The largest observed difference in reaction time variance relative to the control was also found to be in the first trial with a mean percent difference of 93.25%. The values for each of the findings are further summarized below in ***Table 2.***

P-value
Trial 1 Reaction Time vs Control
Trial 2 Reaction Time vs Control
Trial 3 Reaction Time vs Control

Trial 1 Reaction Time Variance vs Control
Trial 2 Reaction Time Variance vs Control
Trial 3 Reaction Time Variance vs Control

Table 1. *Statistical significance for each condition relative to a control*

TV show	Podcast	Music
Average Percent Increase in Reaction Time	9.79%	4.02%
Average Percent Increase in Reaction Time Variability	93.25%	60.30%

Table 2. *Average Percent Increase in Reaction Time and Reaction Time Variability for each condition*

An unequal variance two-tailed t-test was used to determine the statistical significance of these findings, and the resultant p-values are listed above in ***Table** 1*. Following a 95% confidence level, it was determined that both the reaction time and reaction time variance for trial 1 (television) expressed a statistically significant difference. The remaining trials' reaction time and reaction time variance were not found to have a statistically significant difference.

Discussion

This study sought to determine how the intensity of a distraction - designed to encourage multitasking - affects cognitive performance. The activity that related to the lowest performance in the reaction time test, as well as the highest reaction time variability, was television. As seen from the collected data, the trial that involved watching television corresponded to the greatest increase in recorded reaction time and highest variability in reaction time. Distractors that involve both visual and auditory distractions, as well as engaging content, are determined to be detrimental to reaction time and should certainly not be performed during crucial tasks. Other distractors, i.e. listening to music or a podcast, showed evidence of negatively affecting reaction time, but did not do so with statistical significance.

Both reaction time and reaction time variability were used as metrics of focus to determine the level of distraction and the corresponding level of engagement participants felt from each trial. In regard to audio distractions (music, podcasts), there was not a statistically significant difference found to indicate whether that category of distractor had an impact on reaction time or reaction time variance. It is likely that in the last two trials the lack of difference between the control and experimental variances is indicative of a poor level of engagement and thus a low level of distraction, but whether this is due to audio distractors having a minimal effect on focus or if the participants did not find music or podcasts that truly engaged them is unable to be determined.

The results of this experiment show how different types of distractions can affect cognitive functioning. Driving while listening to music may not pose a threat, but doing so while watching distracting media or listening to a podcast could be harmful. Even doing homework or listening to a class lecture while watching T.V. could be detrimental to one's ability to perform. A major factor in both reaction time and the ability to multitask depends on the individual. Previous studies have investigated the differences in multitasking ability in men and women [6]. Other studies show a correlation between reaction time and caffeine and other external factors [7].

Multitasking is a common activity performed by humans, but it is clear that cognitive functioning is impaired during multitasking events and can lead to a lowered performance in important tasks depending on the intensity of the distraction. While it cannot be concluded that the presence of music or podcasts directly affects reaction time, it was observed in the study that engaging with television was a viable source of distraction that slowed reaction time. Additional controls added to the study to ensure a proper level of engagement with each of the tasks would have been beneficial, as the lack of conclusive results from the final two trials indicates low focus among the subjects when presented with audio distractors. Regarding the conclusion that watching a television show slows reaction time and increases reaction time variance, more research would be necessary to see how this effect could be observed — if at all — in a variety of contexts. Future testing would also need to be performed to determine how the level of detriment to reaction time correlates with task proficiency and how well this effect can be seen in everyday life.

Supplementary Figures

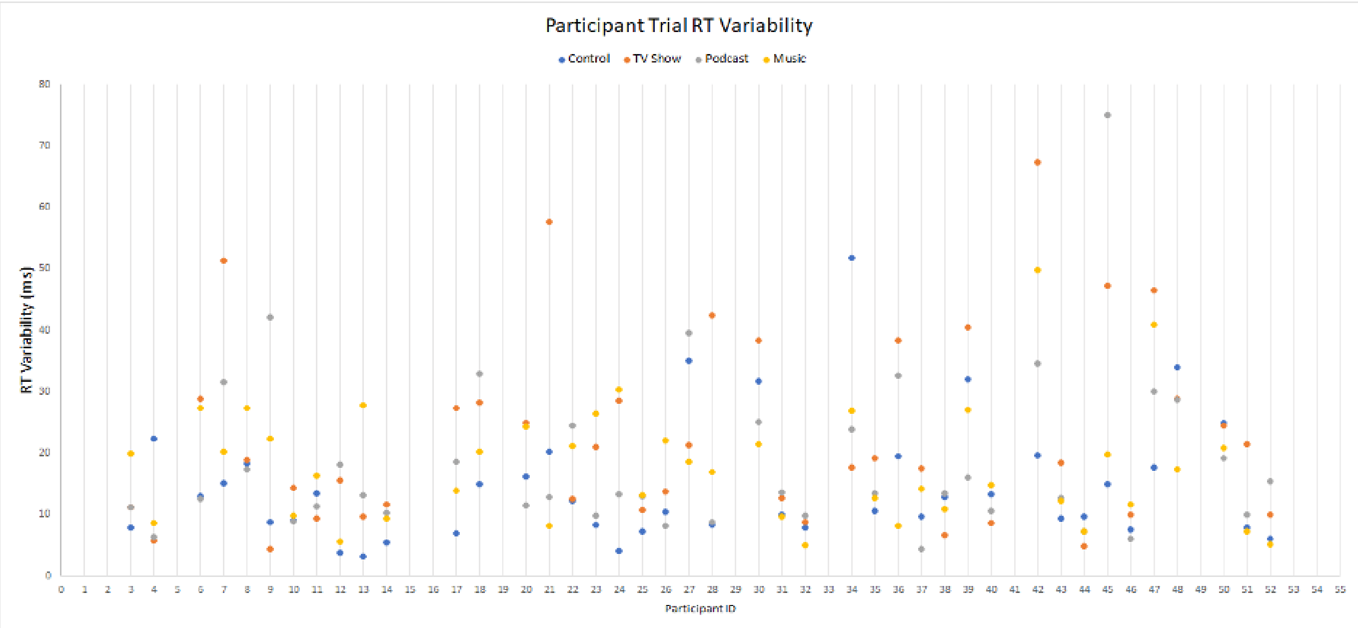

Figure 5. *Reaction time variability averages for every trial of each participant*

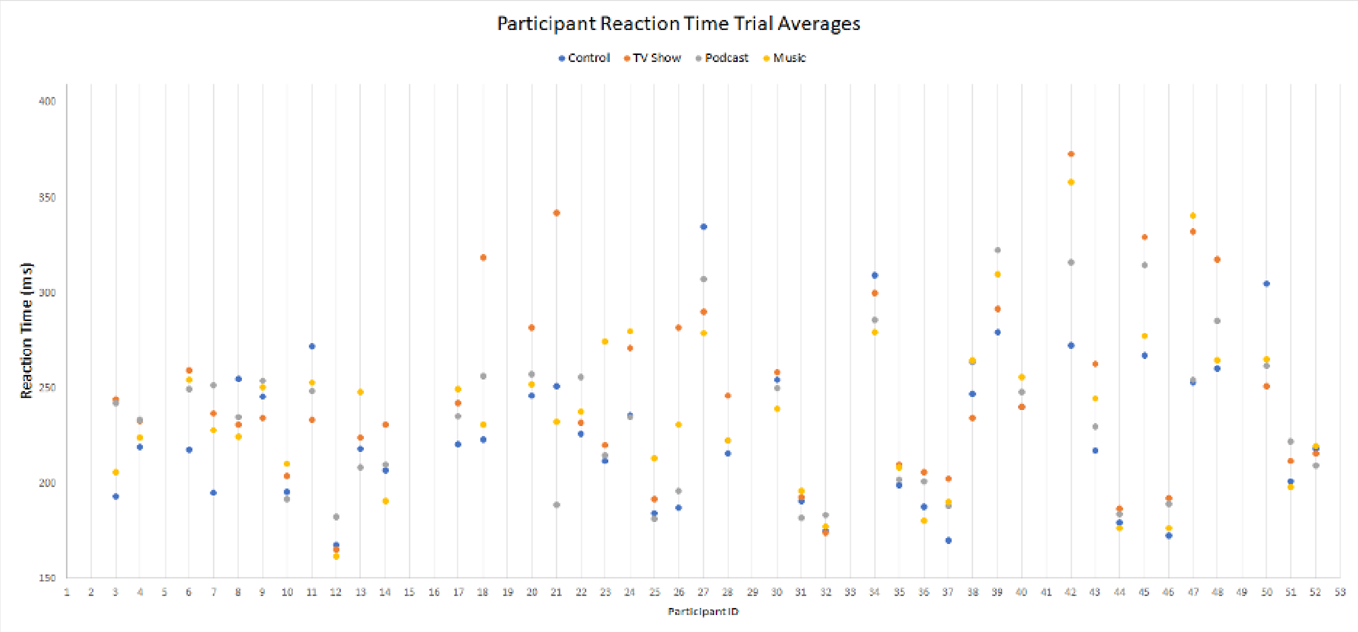

Figure 6. *Reaction time averages for every trial of each participant*

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