Passenger-Driver Distinguishing Test for Pokémon Go

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Distracted driving while gaming is a serious hazard especially for young drivers. Increasing popularity of augmented reality games may increase distracted driving incidents. The main purpose of this study is to test the feasibility of an identification test to differentiate between drivers and passengers to prevent drivers from playing augmented reality games while driving to reduce distracted driving incidents. We hypothesized that increased cognitive burden will reduce vigilance on the secondary task which will reduce attention and increase the risk associated with the secondary task. An experiment with a driving simulator tested university students' performance to evaluate the efficacy of the distinguishing test. The results show that the test shows promise to distinguish between drivers and passengers. Such tests can be used in applications when users perform two tasks that require the same modality leading to decreased performance in both tasks.

INTRODUCTION

Playing games or texting while driving is prevalent and is known to significantly increase crash risk. According to the National Highway Traffic Safety Administration (NHTSA), for 2012-2014 period, motor vehicle crashes were the leading cause of death among 16-24 year olds. The American Automobile Association states 59% of all crashes among young drivers involve distractions within six seconds of the accident (AAA Foundation for Driving Safety, 2007-2015). A recent phenomenon that has contributed to driving distractions is gaming while driving. Research shows that for the augmented reality game 'Pokémon Go' during a limited timeframe window of ten days there were more than 110,000 discrete instances where drivers or pedestrians were distracted while playing Pokémon Go (Ayers et al., 2016).

In recent years, some solutions were put forth to prevent drivers from playing games while driving involving banning play near intersections or highways. However, these solutions require public ordinances that require an enforcement task force. These solutions also reduce the pleasure of playing the game for other stakeholders such as passengers or pedestrians. As the popularity of augmented and virtual reality games increases, there will be a need to balance game playing freedom and public safety to reduce the burden on the healthcare system; simple human factors engineering shows promise to solve this dilemma.

BACKGROUND

Pokémon Go version 0.41.2 for android and 1.11.2 for iOS by Niantic, Inc. that came out on 10/10/2016 (latest version at the time of writing) is an augmented reality game wherein players make use of their smartphones and their GPS location to track and catch Pokémon characters in a real-world location. Pokémons are fictional creatures from the popular video game, anime series.

Ong (2016) states that exploration of real life locations and the worldwide popularity of Pokémon combine to make this game a uniquely attractive experience. Most video games are played while sedentary but Pokémon Go requires users to physically move around to make any kind of substantial progress in the game. Pokémon Go has managed to merge augmented reality and multiplayer gaming. This will likely make it a pioneer for more successful works (Parish, 2016).

The game received praise from the healthcare sector for encouraging common users to walk in order to progress (Ong, 2016). A unique feature in the game is that in order to find rare Pokémons and advance to higher levels, players not only need to walk more miles but go further off from their frequently visited locations. Due to a competitive spirit and mostly sedentary lifestyle, a counterproductive effect was produced. To reach far off destinations players started using the application while driving resulting in a dangerous situation where an interruption from the Pokémon Go application notification can result in prolonged cognitive absence by the driver while the driver's cognitive capacity is diverted towards performing tasks in the application to advance further in the game. This behavior of distracted driving where the players make maximum use of the distance traveled during a day to get further in the game can result in mishaps for not only the drivers but also for pedestrians.

Recently a driver was distracted while playing Pokémon Go, drifted off the road and crashed into a tree (Mason, 2016). In another instance, a driver in Japan did not notice two women crossing the street because he was distracted while playing Pokémon Go, struck both of them with his small truck, killing one of them and seriously injuring the other, (MacCormack, 2016). A twitter entry states,

"*I was sitting in my parked car when a van hit it. He was playing #Pokémon Go and didn't see me. I too was playing. This game will kill us all.*" (Sir Wrender, 2016)

The game has counterchecks against this effect. A safety message and a check mark box appear on screen if the application is open while in motion above a certain speed limit (currently restricted to ten miles per hour). This allows passengers to play the game because they are not considered a public safety risk (Ayers et al., 2016).

In addition, Pokémon Go, in its update on 8/4/2016 changed its coding so that Pokémon only stay visible for 70 meters. This works hand in hand with the slower scan refresh rate (Morrow, 2016; Hoffer, 2016; Jh, 2016). The new refresh rate will make it more difficult to see and catch Pokémon while traveling at speeds that are more than ten miles per hour. Due to this change, if a user is in a car or riding a bike, it is much more likely that the game will not detect Pokémon while driving or they will disappear from the screen before users have a chance to catch them. Even with the updates, some Pokémon will pop up in a Pokémon high-density area and Pokéstops ("Pokéstops are fixed locations in the real world that dispense complimentary game advancement gear like Pokéballs to catch Pokémon", Ong, 2016) do stay visible traveling at any speed. These updates may not deter drivers from playing the game while driving, as there is at least a chance to collect items from Pokéstops and the occasional Pokémon.

Suggestions to prevent drivers from playing the game are to restrict game access for a specific time period after a certain speed limit has been crossed or restrict access to the game near highways, parking lots or intersections to protect pedestrians from distracted drivers. In the first case, private car passengers or public transport passengers would not be able to access the game even though they pose no risk to public safety, restricting access to the game might add to their frustration which might not be in the best interest of the game developers. In the second case, drivers playing the game while driving are still a threat to other drivers on the road even if there is no intersection or parking lot nearby and access restriction might also provide an additional distraction to the drivers. For example nearing an intersection, the application restricts access and the driver spending few moments trying to interpret the reason for the shutdown leading to additional distracted driving incidents. Currently, no game advancing features such as Pokéstops or Pokémon are located close to highways, however as the highway crosses a population center, game advancing features start showing up at specific GPS locations resulting in distracted driving near highways.

LITERATURE REVIEW

Horrey & Wickens (2007) among others state that performing a complex in-vehicle task does not necessarily increase crash risk because the in-vehicle glance duration average may be within permissible limits. It was found that an interruption of any kind or degradation in performance during the visual scanning process of the driver can and will cause reduced situational awareness (Salmon et al., 2011). Horrey & Wickens's (2007) driving simulation study shows that 80% of the crashes happened when the glance duration (inside the car) was higher than 1.6 seconds. Liang et al. (2012) stated that there is a correlation between driver glance patterns and crashes or near crash risk to the duration of glances that a driver takes away from the road. Strayer et al. (2003) stated when distracted, drivers will divide their attention between the primary task of visual information gathering (driving) and secondary tasks that do not have the same relevance with respect to driving. Harms (1991) showed that driver's cognitive load is higher in the non-urban areas or city roads as compared to the highway.

Working memory and information processing literature posits that there is a limit to human visual short-term memory capacity. Rousselet et al., (2004) stated the human brain has a huge side-by-side processing capacity that permits successful decoding of complex images in 100 milliseconds. The limitations to this capacity are 1) Consciously isolating the visual stimulus in the 'visual short-term working memory' (VSTM) as indicated in the 'attentional blink paradigm' by the authors; 2) Limitations to the number of stimuli that can be held at one time in the VSTM; and 3) Selecting a response from alternatives approaches to each stimulus (Raymond et al., 1992). Same and different modalities affect the information processing with little or no effect on processing capacity for different modalities (Chun & Potter, 2011; Soto-Faraco & Spence, 2002). Although VSTM capacity is estimated to be about four items, this is not set by just the number of items present but also by the complexity of each object stored in the VSTM (Coven, 2001; Luck & Vogel, 1997; Alvarez & Cavanagh, 2004). Reimer et al., (2012) showed horizontal gaze concentration increases or there is a decrease in gaze dispersion when there is an increased cognitive demand from information gathering.

Day et al. (2011) stated, "Driving performance is affected in a detrimental manner by both visual interference tasks and visual delays". This phenomenon can be explained by visuospatial working memory disruption. The technique drivers' use for compensating for this phenomenon is not concentrating on the visual interference task, as doing so will reduce the driving performance.

Hypothesis. We hypothesize that if the cognitive capability required for a particular task (in this case trying to play Pokémon go) and driving at the same time is higher than visual short-term memory (VSTM) capacity, drivers will find it difficult to drive and play at the same time.

Driving has aspects of controlled processing which augmented reality games disrupt leading to increased risk of driving. According to the s-r-k framework (Rasmussen, 1983), driving requires a combination of skill-rule and knowledge-based behavior with data collection, data interpretation along with course correction actions based on the interpretation.

METHOD

To prevent drivers from playing the augmented reality game while simultaneously driving, a Pokémon go identification test was introduced that works whenever the driver crosses the designated speed limit set by the game to verify if the user is a passenger or a driver. The passenger test will increase the cognitive burden as it decreases the cognitive capability being used towards the two visual tasks. In such time constrained environment, the working memory will be filled with data from the test and a cursory glance at the road will erase that test data to make way for road information and driving environment (visual data). The time factor will make it difficult to perform the two tasks simultaneously as the cognitive capacity might not be sufficient under that time pressure. Information processing will be slower than required which will either result in failing the game's passenger test or significantly increase the risk for traffic crashes or violations. For most people that would mean reducing crash risk and not playing the game while driving.

Repeated failures at the test will deter drivers from trying to play the game, as the test will act as a safety lock, resulting in fewer accidents due to distracted driving.

Test Environment

The experiment took place in a university lab, the lightning, noise (<50 dB) and temperature were maintained at a comfortable level for humans to avoid introduction of independent variables. The environment was generic enough to be reproduced in a typical university lab.

Participants

The participants were college students, a demographic that likes to play games and have the license to drive. Ten participants were studied with mean age = 24.8 years, standard deviation = 1.81 years, male/female=6/4, all participants had a valid driving license, had no alcohol consumption prior to the experiment and had at some point at least texted if not played games during driving.

Apparatus

The STISIM Drive® M100 system from STISIM, a driving simulator that runs propriety programmable STISIM Drive® software engine was used in this experiment (STISIM Drive, 2016).

The mobile used for the passenger test was an iPhone 6 model with 4.7-inch (diagonal) LED-backlit widescreen.

Procedure

Driver identification test. A simple memory task would appear on the screen randomly between 2-4 seconds and users need to answer a question based on the text. The identification test can be built into the application and would appear on the screen as the speed of travel exceeds the preset limit. The user would be prompted to take the identification test in order to prove they are not driving the vehicle. The users would have to get a series of five correct answers to complete the test and a wrong answer in between would restart the test. Sample questions from the test are shown in table 1. Each data set has four numbers and the questions are based on the spatial arrangement of those numbers. To make it further difficult for users, having four items was chosen from Coven's (2001) work stating VSTM can hold four items. The participants would have to manually type in their answers. The test is designed such that the user would require continuous attention for 3-6 secs to read, gather information from the text and answer the question using their working memory. The question would be displayed randomly for 2-3 secs and the user would have 2-3.5 secs randomly to answer the question. The next question would then be displayed on the screen as soon as the user provides an answer or time expires. This will prevent drivers from frequently glancing at the road. The entire test should not take more than 32.5 seconds to complete for the worst randomization.

Table 1. Representing sample data set and questions related to the data set that is used in the test.

Sample Data Set	Data Set Question
12, 04, 54, 77	What was the second number in the text?
24, 52, 91, 43	What was the first number in the text?

The test would be easy for a user that is a passenger as they can use their full cognitive focus to complete the test whereas driving trying to complete the test would require splitting cognitive capability between the two tasks. This would result in cognitive overload or considerable difficulty for the user.

For the experiment, the participants were given a set of eight questions and were graded on how many questions they correctly answered. The participants were given two such sets with an interval of five minutes between each to reduce fatigue.

Simultaneous driving and identification test task. Participants were asked to complete a driving simulation task that required them to drive a simulated vehicle on a suburban street with one lane in each direction and parked cars on both sides of the road. Surprise events consisted of a pedestrian and a dog walking onto the street in front of the car. There were three stop signs but no intersections. Participants were required to complete the circuit with no crashes and no traffic violations. This scenario was a typical commute for people who would like to play the game while driving. The participants were asked to complete the driver identification test and drive at the same time with the objective to complete the test. They were also required to drive at a minimum speed of 20 miles per hour unless required to stop at a stop sign or to avoid a collision.

Crash and traffic violations committed by the participant were recorded by the software, including speed limit violations. A crash will end the test as the windscreen was shattered in the simulation software.

The participants were provided pilot question sets to get accustomed to the reading and memorization task. The participants had a practice session on the driving simulator to get accustomed to the controls and dynamics of the driving task.

Data Analysis

Univariate analysis was used for data analysis and general linear model (t-test) was used to test the statistical significance.

RESULTS

The results of the experiment are provided in table 2. The primary performance measure was answering correctly the questions to the test in a series. For example, if a person had a performance of CCWCCCWC in a series for an eight-question set where C (correct) and W (wrong), their performance was three (3) correct answers. As the participant could answer three correct answers in a series.

Table 2. Representing parameters that were measured from the experiment and statistical data analysis values.

Test Parameters	Numerical Values
Mean for driving and memory test	3.4 (number of correct answers in a series)
Mean for memory test	4.7 (number of correct answers in a series)
T-test value for a two-tailed test	2.14
P-value (significant for p<0.10)	0.061

DISCUSSION

The simulated driving task showed promise in providing the opportunity for participants to test the limits of their cognitive capability while simultaneously performing two visual tasks of driving and solving the identification test. This may provide evidence for efficacy of such tests in identifying drivers from passengers in the context of playing virtual reality games while driving.

Our inference from the results are that the competitive spirit and cognitive load of the test for processing and memorizing information under a time constraint pulls cognitive resources away from the driving task as users tend to concentrate on answering correctly. As the test requires more information processing, other vigilance tasks are blocked, leading to focused attention that greatly enhances the risk of crashes while driving. Focused attention can lead to improved decision making and increases the chance of failing the test as drivers start to focus on the driving task that has comparatively greater risk associated with it.

An interesting observation was the difficulty experienced by the participants to get five correct answers in a series for four two-digit numbers than three three-digit numbers or even two four-digit numbers, each having a similar number of digits but separated by commas. Further investigation is needed into the analysis of chunking of information related to numbers for short-term memory with respect to the number of digits used in the design of similar experiments. One explanation for this phenomenon may be the perceived level of difficulty, as four two-digit numbers be perceived as more complex (four chunks) than three three-digit numbers (three chunks). Future research should investigate how cognitive processing works for numbers under a time constraint for short-term memory. This can be useful in interface displays where numbers are represented in a series in a time critical application.

In addition, since the scenario contained suburban low traffic density, there were not many crashes, but participants exceeded the speed limit in more than 80% of the cases. The reasons for this need to be analyzed by a separate study focusing on this phenomenon.

There are several limitations of the study that may affect the generalizability of the results. The most important limitation was the small sample size. The experiment considers average risk-taking behavior to design the test; i.e. participants are responsible citizens and do not want to crash or violate traffic rules blatantly in order to play the game. In addition, the lab experiment was not able to capture all the circumstances of a real-world situation. Another limitation was the test would also be somewhat irritating to genuine passengers and ways to mitigate that would need to be investigated. Currently, it is not possible to detect drivers playing the game while driving at five miles/hour or less on residential streets.

The success of the differentiation task can be attributed to the high level of difficulty that takes the opportunity to utilize divided attention. More research is needed to investigate the optimization of the identification test in order for average passengers to not have difficulties in taking the test. More research is needed to determine how random numbers in the test affect the reading time required for the test. For example, if the test contains three numbers above 70, then the reading time is greater than for the sample that contains only one number above 70; the sensitivity of this variable needs to be further tested. The scenario used for the test was low suburban vehicle density with few surprising events in between; use of various scenarios in future studies can be used to analysis participant's test completion sensitivity. The age of the users was not a variable in this test, and future research might look at different age groups. This experiment did not consider differences between the sexes with respect to simultaneous multitasking.

Future studies could also look at how a focus on a visual-information-processing-cognitively-intensive task affects motor function for an activity performed simultaneously with that visual task (for analyzing the large amount of speed limit violations). Instances of passengers encouraging drivers to take risks like unscheduled stops in traffic or impromptu turns that can result in accidents need to be analyzed.

CONCLUSIONS

A simulated driving study was conducted to evaluate a method to prevent drivers from playing augmented reality games while driving to prevent distracted driving incidents. The study evaluated how deliberate or forced interruptions from switching between two primary visual cognitive tasks affects the working memory, in this case driving and completion of a memory task on a handheld device. Our preliminary findings show that such an identification test shows promise to distinguish between passengers and drivers using principles of focused attention, visual short-term memory, and cognitive information processing. Such tests can be used to deter drivers from playing games while driving and will not restrict passenger's freedom to play games while in motion. These tests can also be used in monotonous tasks to increase vigilance, block out distractions, or for tasks that require more focused attention.

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