Dramamine

BMED 3110

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Effect of Visual Distractions on Varying Reaction Time

Abstract

Distraction related accidents have become a significant problem in the US potentially due to the increased presence of visual and cognitive distractions in and around cars, which may lead to an impaired reaction time. Our team set out to determine if visual-cognitive distractions led to a significant increase in reaction time. We developed an online test where subjects were instructed to track three moving circles among a varying number of moving shapes (distractions) and to press the space bar (response) when one of the circles turned blue (stimulus). We recorder the reaction time as the time between the stimulus and the response, and analyzed the data by comparing each attempt to the basal reaction time (obtained by using one stationary circle) and all other attempts, using paired one-sided t-tests, and by ranking the responses (0 being the fastest response and 19 being the slowest). The results revealed that all scenarios produced a significant increase in reaction time when compared to the basal measurement and that all values corresponding to more than 20 distractions resulted in a significant increase in reaction time when compared to distraction values less than 5. Our data also revealed a positive correlation between the ranks data and the number of distractions that levels out after 20 distractions, which is consistent with the comparisons data. Thus, our team identified a ratio of 20 distractions per 3 circles as a possible threshold value above which reaction time is significantly impaired.

Introduction

Driving safety has become a field of increasing interest for biomedical applications. While injuries resulting from accidents such as brain and spine trauma are a target for areas of research, new efforts are being focused on developing preventative measures to increase driver safety and reduce distractions. Medical departments at several universities across the country are currently working on research projects into safety technologies and protocols (Nystrom). Similarly, peer reviewed research has explored fatigue and sleepiness and its potential causal role in car crashes (Connor).

Distracted driving has become an increasingly relevant problem in the US, with 9 people being killed and 1,153 injured daily as a result of traffic accidents involving a distracted driver ("Distracted Driving", "What Is Distracted Driving?"). Visual, manual and cognitive distractions are factors that may decrease a person's reaction time, or the time it takes for one to respond to a stimulus such as the brake lights on a vehicle in front of you or a traffic light, thus increasing the likelihood of an accident. Several studies have already investigated the effects of texting while driving and found that a driver's risk of being in a car accident is significantly increased while the driver is texting and even immediately after texting has stopped (Thapa).

With the increasing presence of user interface screens in car dashboards, GPS devices, and side of road distractions; there is potential for a chronic threat to driver safety. There is a need to explore the effects of this type of dual visual-cognitive combined distraction, and its potential causal role in car crashes. Our team is interested in determining whether having visual and cognitive distractions present causes a significant increase in reaction time, and if so at what distraction threshold is reaction time significantly impaired. We hypothesize that the presence of a visual and cognitive distraction will increase reaction time as compared to reaction time with no distractions present.

Materials and Methods

Twenty-two current BMED 3110 students served as subjects by taking a computer based reaction time test (available at 3110.firebaseapp.com) that was coded by one of the research team members. The test subjects were allowed to take the online test on any computer with a functional spacebar in a quiet setting. The subjects were instructed to press the space bar when any circle on the image screen turned blue in color.

The first sequence on the test was used to test their basal (control) reaction time, where they had one circle in the center of the screen of either yellow or red color. The control test was performed 4 times and the minimum value was taken as the control.

The experimental conditions each contained exactly three circles randomized to be either red or yellow (items needed to track) as well as a varying number of distractions (additional squares and triangles present in varying quantities and randomized to red, blue, or yellow). All shapes moved at a randomized velocity onscreen. The test measured the reaction time as the time elapsed between the circle's color change (which occurred within a random interval) to blue and the subject's pressing of the spacebar. In the event that a subject reacted prior to the stimulus then the timer for the stimulus to occur was reset, delaying the test and therefore preventing false results, without introducing an artificial penalty. Once the test subjects reached the completion screen, the reaction time data was automatically exported and saved for further analysis.

The reaction time data was normalized per equation 1, such that the control reaction time (which is expected to be the minimum) would give a normalized reaction time of 0 and the maximum reaction time would be 1. The distraction ratio (DR) was also calculated per equation 2, such that the minimum number of distractions would equal to 0 and the maximum would approach 1. Plots were generated for the normalized data (mean RT_{norm} vs. DR) as well as for the raw data (mean RT vs. distraction number).

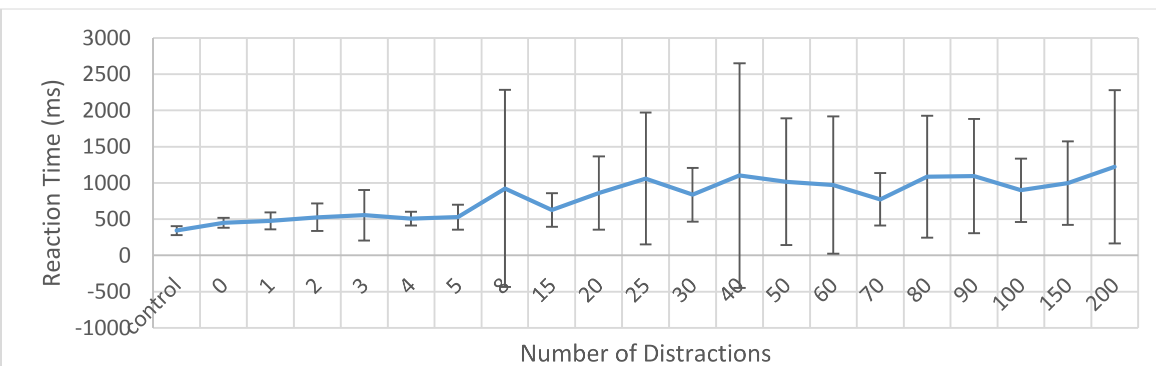
Equation 1: $$RT_{norm} = \frac{RT_i - RT_{control}}{RT_{max} - RT_{control}}$$

Equation 2: $$DR = 1 - \frac{number\ of\ circles\ (3)}{total\ number\ of\ objects}$$

Although we initially intended to perform all the analyses on the normalized data, we determined that it would not be an appropriate way of looking for significant differences among groups, since our normalization procedure greatly altered the variance of our data. Thus, to determine if there was an increase in reaction time between the controlled and experimental scenarios, the raw data from all attempts was compared to the control using a paired one-tailed t-test using an α = 0.05. Similarly, the raw reaction times were compared to each other using one sided paired t-tests to determine if there were significant increases in reaction times due to an increase in number of distractions. Lastly, the raw reaction time data was ranked by assigning a zero to the number of distractions that corresponded to the fastest reaction time, a one to the second fastest, and so on, giving the highest rank to the number of distractions with the slowest reaction time. The ranks data was plotted to determine if there was any correlation between the two variables.

Results

Figure 1 shows the relationships between reaction time and number of distractions, while data Table 1 (found in the appendix) summarizes the results from the comparisons. Values highlighted in green correspond to a significant increase in reaction time per our definition. Briefly, all experimental conditions seemed to significantly increase reaction time when compared to the control. We observed that the block corresponding to comparisons between distraction numbers of one through five with distractions above 20 showed significant increases in all but one case (p = 0.06). Based on this, one could select 20 distractions as a cutoff for significant increase in reaction time. Figure 2 shows the means of the ranks as a function of distraction number. One can observe that although there is a poor linear fit between the data and distraction number, there is a slight positive correlation between the two variables.



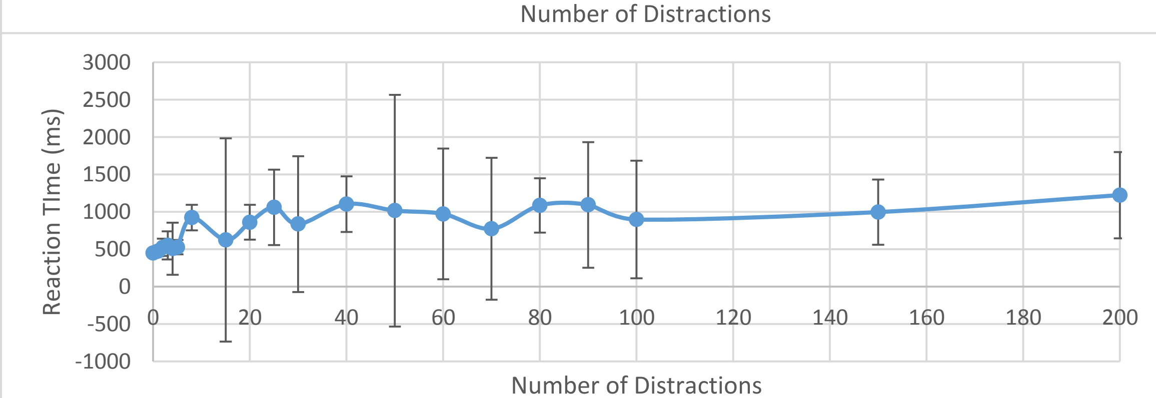
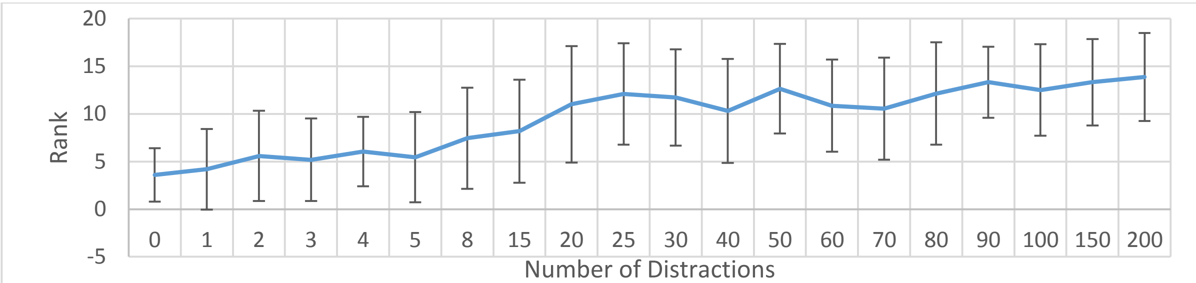


Figure 1. Mean reaction time as a function of distraction number. One standard deviation is shown by error bars. Control is shown for reference on the first graph. The first graph contains

a sample by sample scale to highlight detail. The second graph contains a linear scale to highlight scale.



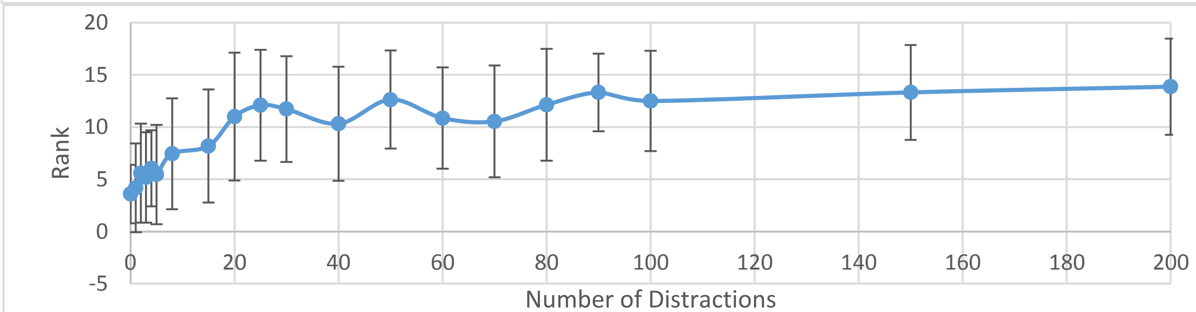


Figure 2. The plot of the ranks vs. number of distractions reveals a weak positive correlation between the two variables. One standard deviation is shown by error bars. The first graph has an item by item scale. The second graph has a linear scale. It can be seen by the second graph that there is a sharp slope up to 20 distractions, followed by a leveling off.

Discussion

All experimental scenarios yielded a significantly slower reaction time than the control scenario (which was aimed at obtaining the fastest possible reaction time for each individual, and which lined up with literature suggested values, with a mean of 342 ms). This suggests that in a task that requires an increased amount of cognitive effort such as tracking moving objects, a subject’s reaction time is already impaired as compared to when dealing with a single, non-moving object. This implies that people’s reaction times will be slower than usual just due to driving alone. Table 1 also reveals that not all levels of distractions were significantly different from the 0 distraction condition. We did however identify a threshold for which all but one of the increases in distraction number corresponded to a significant increase in reaction time. The block of green values that range from comparing 20-200 distractions to 0-5 led us to determine that a distraction level greater than 20 objects on the screen would significantly impair reaction time when compared to 5 or less objects on the screen. This suggests that there may be a threshold distraction level at which an individual's ability to respond to the desired stimulus would be significantly impaired. Although we identified this level as a ratio of 3 circles to 20 distractions in our test, further research is needed to determine what this value in a driving scenario. Lastly, the results from our ranks data revealed an upward trend: on average, people responded slower to the stimulus when there were a large number of distractions present and responded faster when the distraction number was less. Further analysis into this graph reveals that the steepest increase in ranks occurs between 0 and 15 distractions, while the increase in ranks levels out after 20 distractions, which is consistent with our comparison table analysis.

Our test has multiple limitations, such as the extent to which it resembles a driving scenario and the use of one measurement per subject per distraction number (rather than an average of multiple attempts). In order to make this experiment more relevant to a driving scenario, a better metric might be measuring brake time (or the time elapsed between the occurrence of a stimulus and the pressing of the brakes pedal with one's foot) within a simulator. However, because of the general nature of this study, it could potentially be applied to other scenarios; for example cockpits, video games, sports, and operating rooms. If we were to repeat this experiment in the future, we would record averages for each distraction number within a more specific and realistic setting. Furthermore, a number of variables were randomized, for example color and velocity, these variables should themselves be studied.

Conclusion

The results from our experiment suggest that cognitive and visual distractions can lead to a significant increase in reaction time when the level of distraction is above a certain ratio (in this case corresponding to 20 distracting objects per 3 circles). This means that having dual visual-cognitive distractions present could cause a delay in driver response ability, thus increasing their likelihood of being in a car accident and endangering the safety of others on the road. Future research should be done into existing screen interfaces and GPS devices in cars to attempt to minimize the distractions they cause to divers.

References

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	Distraction Number																			
Comparison Against	0	1	2	3	4	5	8	15	20	25	30	40	50	60	70	80	90	100	150	200
Control	1.2391E-09	1.66E-05	7.55E-06	0.003797	5.33E-09	4.02E-05	0.025214	3.39E-06	5.21E-05	0.0008	5.1E-07	0.013782	0.000817	0.00186	1.3E-05	0.000193	8.15E-05	2.37E-06	1.63E-05	0.000463
0		0.099412	0.020661	0.075195	0.006971	0.015808	0.053289	0.001078	0.000544	0.003034	2.25E-05	0.027925	0.002983	0.007166	0.000339	0.000822	0.000399	5.38E-05	0.000121	0.001484
1			0.127985	0.150011	0.19533	0.125965	0.067648	0.004957	0.000631	0.004111	8.91E-05	0.034477	0.005332	0.011952	0.001091	0.001496	0.000606	0.00023	0.000295	0.002336
2				0.364153	0.30459	0.496455	0.091344	0.066351	0.002676	0.009132	0.000978	0.047385	0.010645	0.01933	0.008558	0.002772	0.000656	0.000141	0.00095	0.004069
3					0.24632	0.382211	0.114974	0.166933	0.01	0.017112	0.010578	0.060304	0.018738	0.029774	0.032536	0.008074	0.003718	0.00581	0.002452	0.004979
4						0.3217	0.078571	0.018161	0.001581	0.005819	0.000372	0.041185	0.005995	0.013302	0.002004	0.002477	0.000661	0.000129	0.000331	0.002223
5							0.094235	0.091079	0.003479	0.008196	0.000988	0.048576	0.006464	0.022168	0.003038	0.002909	0.001305	0.00059	0.000445	0.00336
8								0.153529	0.423201	0.355324	0.367159	0.135357	0.395142	0.388852	0.314862	0.300644	0.290253	0.465281	0.413464	0.223428
15									0.029559	0.024026	0.009138	0.076175	0.031441	0.048115	0.047449	0.006444	0.007071	0.005583	0.007892	0.010721
20										0.210026	0.428439	0.256187	0.26328	0.315658	0.175423	0.179355	0.080696	0.379114	0.232718	0.104737
25											0.157045	0.460047	0.429132	0.388512	0.096042	0.462755	0.451086	0.232634	0.37324	0.112211
30												0.186123	0.181898	0.218895	0.274275	0.094939	0.088431	0.315425	0.131282	0.072438
40													0.407982	0.249573	0.177715	0.478427	0.490574	0.280683	0.386248	0.390217
50														0.437818	0.113597	0.396087	0.37209	0.275689	0.435996	0.031596
60															0.180535	0.317229	0.311392	0.368461	0.460718	0.22155
70																0.065927	0.056902	0.118524	0.075035	0.042582
80																	0.486506	0.202026	0.350227	0.304285
90																		0.098444	0.304148	0.328723
100																			0.261332	0.109895
150																				0.163674

Table 1. Summary of p-values for series of individual paired t-tests one tailed t-tests with expectations that the more distractions, the greater the reaction time. Green cells indicate a significant increase in reaction time ($p < 0.05$).

Appendix