The Impact of Visual Distraction on Reaction Time in Spot It!

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1.0 Introduction

Distractions are integrated into every aspect of life and understanding the effect distractions have on visual processing and distinguishing features in images can help create conclusions regarding the impact distractions have on accuracy. The purpose of this project is to examine how distractions affect the speed at which individuals react to visual stimuli. The experiment is in the form of a "spot the difference" game and tests participants' speed and accuracy in completing the tasks. Participants were presented with two images that slightly differ from each other and were asked to identify the different figures that were not consistent. The visual distraction used at each level of the experiment gradually increased to examine the effect distractions have on the speed and accuracy of completing the tasks. Based on a brief literature review conducted (see Appendix A), the team found that the addition of a distraction is not enough to impair performance instead the specific type of distraction [1] impacts the accuracy of a task being completed. Further, the literature review showed that there is a relationship between a distraction and attention because the distraction must be processed which takes away from the completion of the task [2].

2.0 Experimental Method

The following sections describe the experiment and how the team collected the data. This includes an explanation of both the independent and dependent variables, the data collection procedure, and a description of the participants included in the study.

2.1. Procedure and Tasks

The experiment commences with a team member sharing their screen, containing the presentation of the experiment, with the participant on a zoom call [Appendix B]. To begin, the team member explains the purpose of the experiment and asks the participant if they are willing to have their identity and responses recorded and used for the team's data collection. After verbal confirmation from the participant, the team member fills out the Google Form capturing the participant's first and last name, age, and gender as described in section 2.4 [Appendix C]. If the participant does not give permission for their data to be recorded, they cannot proceed with the experiment and a new participant must be found. Once the user profile is collected, the participants are told the following instructions:

1. You will be shown two cards with various images on them and will be told how many total differences you are looking for.

2. You will be given 20 seconds to compare the original image card to the changed image card.
3. After 20 seconds, you will be shown the original image card again and be asked what figures are not on the changed image card.
    a. The team member conducting the experiment will take note of the participant's response time in seconds, which begins the moment the slide is switched to only show the original card until the moment that the user is done listing what they thought to be the different images.

To avoid any misconceptions or confusion as well as to simplify the experiment, the participants were asked to keep the following two considerations in mind before proceeding.

- Position and size do not matter when comparing the images
- Keep note of only the images that are not on the other card, all other differences are negligible

2.2. Independent and Dependent Variables

The independent variable for this project is a visual distraction which acts as a categorical factor at three different magnitudes. As discussed in the section above, each participant will take part in identifying the number of differences between two cards with images of flowers that have a specific visual distraction level. For the easiest level, participants will be shown two sets of flowers, where each set is placed on the same white card and a contrasting black background, making the flowers stand out without a visual distraction (see Figure 2 for the cards included in the first distraction level).

Figure 2: The two cards shown to participants for the first distraction level experiment

The second set of participants will encounter an increased level of visual distraction in the form of a new set of flowers, now placed on a grey card, all of which is on top of a white background. In addition, the grey cards have a flower stencil that covers the entire card and decreases the

visibility of the flowers (see Figure 3 for the cards included in the second distraction level experiment). Further, each flower is about the same size all semi-clustered together in the center.

Figure 3: The two cards shown to participants for the second distraction level experiment

The final stage of the experiment, given to the third group of participants, consists of the largest visual distraction in the form of all yellow, pink, and red flowers, where each set of flowers is placed on a yellow card with a red background. Further, the flowers are very close to each other and blend into one another. Due to the similar colouring of the flowers with the background and cards, along with the more complex stencil, this stage contains the highest magnitude of distractions given to any of the participants (see Figure 4 for the cards included in the third distraction level experiment).

Figure 4: The two cards shown to participants for the third distraction level experiment

The dependent variables for this project are the participant's response time to recall the differences between the images, as well as the accuracy of their responses with respect to how many differences they found out of the total number of differences for that task. Once the participant finished observing the two cards for 20 seconds, they were shown the original card and asked to recall the differences. Next, the participants were shown the original image only and were on how long it took them to list all the differences they notice. This time represents their response time, which is dependent on the level of visual distraction, and their correlation will be further explored in the later sections. The accuracy of a participant's response corresponds to the

number of correct differences identified between the two cards, represented as a fraction of the number of correct differences divided by the total number of differences. This value represents the user's accuracy (as a percentage) of the total differences, and the relationship between the accuracy within each visual distraction level will also be explored using various statistical methods in later sections.

2.3. Participants and Control Factors

Twenty-four participants were selected to take part in the experiment in accordance with multiple control factors. In order to produce unskewed results, and to minimize experimental manipulations, the team has made the age and gender of the participants control factors for the experiment. All participants are a part of the age range from 19-30 years old, and the team ensured that half of the participants were male and the other half female. These 24 participants were then randomly and equally distributed among the three distractional level experiments, so each one would have 8 participants. Each individual takes part in only one of the experiments. Another bias that may not have been fully controlled, is the measurement bias that could have occurred as the experimenter took note of the participant's response time. Since the time it took most individuals to provide their differences was a very short time period, it is likely that the team was not able to measure the exact time it took the participant to respond and so the relationship was found between difficulty level and response time may be biassed.

3.0 Analysis Methods

This section will describe the data gathered through the team's experiment, compare the different experimental conditions, and draw conclusions from the gathered data.

3.1. Data Gathered

The team gathered data about the time accuracy of the participants' responses. Throughout the three different difficulty levels, the team recorded the number of differences each participant identified between the two images they were presented with. Based on how many differences were identified the team member administering the test would record the participant's response, x, on a scale of 0 to n, where n is the total number of differences. The time it took the participants to state these differences was also recorded as another important data point. In order to ensure the results were expressed as decimal numbers between zero and one, the team divided the participant's number of correct differences identified by the total differences that existed in the given level. As an example, a participant that obtained an accuracy score of 2 when

answering the first difficulty level would have their score converted by doing 2/3 and obtaining a new representative score, approximately 0.6667, that resides between the bounds of zero and one. This allowed the team to use the data gathered about the accuracy of the participant as a continuous variable. As time is already a continuous unit, no modifications were made to this variable.

3.2. Experimental Conditions

The three levels of difficulty created comparable data results. As the type data collected from each set of experiments were identical and the gender distribution was even across all levels, the team found many reactions due to varying experimental conditions. In the first difficulty level, there are fewer images with three images being different between the two presented cards, and the background is white, making it more visible. This allowed the majority of the participants to identify all 3 differences between the two images. The second difficulty level had a coloured background and contained one more different than the first level. This contributed to the added difficulty of the task and resulted in the majority of participants identifying three out of the four existing differences. The third difficulty level included a background with a complex design similar to the images among which the participants were supposed to identify the differences. In this experimental condition, the participants again found three differences out of the five existing differences. It was found that as the difficulty level increased it was generally more difficult to spot all the differences. This can be attributed to the increase in complexity of the background and images that were presented to participants. However, the number of differences spotted across all three remain consistently at around 3 to 4 differences. This suggests a certain capacity for remembering the images presented to them over a 20 second time period that is common in all three participant groups.

3.3 Statistical Analysis Methods

The team modelled the data by performing different statistical analysis on the empirical data collected from the experiment. The first method the team implemented is the Pearson correlation test. This was used to test the team's null hypothesis by determining p-values and whether or not they will conclude in the team rejecting or failing to reject H_o within a 95% confidence interval. This test measured the linear dependence between two variables x and y, and provided a linear regression curve in the form of $y = f(x)$. The test was first performed where the independent variable, x, was set to the three distraction levels, and the independent variable, y, was the

accuracy as a percentage. The test was also conducted with the same independent variable, but with the dependent variable as the response time of the participants. The Pearson test was conducted to compare the vector values of the two variables and not their ranks.

The team then plotted the collected data points and created a linear regression graph that fits this data. As points can often be difficult to interpret, the regression line allowed for a more concrete and accurate analysis of the trend and relationship that exists between both sets of data; difficulty levels vs accuracy percentage, and difficulty levels vs response time. This linear model predicted a value of $\hat{y}$ for future values of x. The team also used the ggsmooth function to model an area around the linear regression line, defined by a line, that allowed for the prediction of the frequency of x given the modelled distribution for f(x) the team implemented. Additionally, the team analyzed the data using the summary function which produced information such as t-test, F-test, R^2, residual values, and significance level. This information can be obtained using the summary function in R, separately, for both sets of data; difficulty levels vs accuracy percentage, and difficulty levels vs response time. The team used this output to predict the relations between both sets of data, and answer important research questions that related to the linear model previously created. In order to obtain more data on the dependent variables, the team will institute an ANOVA test on both accuracy percentage, and response time, both of which will be relative to the distraction levels. This informed the team about the value of the dependent variable in question that will change according to one or more of the distraction levels. It will test the difference in means of the dependent variable in all three levels of the independent variable. The team would like to test H_o where the null hypothesis has both means equal to one another and the alternate hypothesis states that the means are different. This test will provide the team with information about the model residuals, including the model variance. It will state the degrees of freedom, mean squared, sum squared, F-value, and the p-value of the F statistic. Regarding the unexplained variances that result from the ANOVA test, the team produced diagnostic plots to determine their origins. This allowed for conclusions to be drawn about the rejection or failure to reject the chosen null hypothesis. This ANOVA test was performed for both the accuracy and response time data sets.

4.0 Results of Experiment

In order to measure and examine the performance of participants in all three levels of the team's experiment, an R script was created. The team generated a series of graphs plotting the accuracy

and response times of the participants against the difficulty level of the test; these graphs should help gain a stronger understanding of how the difficulty level of the test impacts the accuracy and response time of the participants (see Figures 5 and 6 for scatter plots of each dependent variable against distraction level).

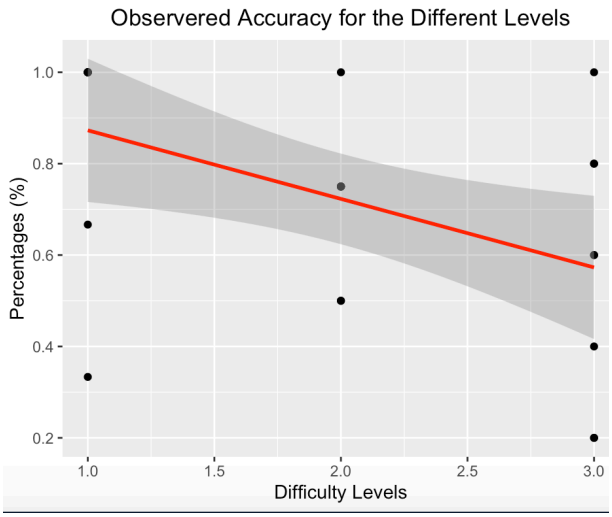

Figure 5: Participant accuracy in percent as difficulty increases

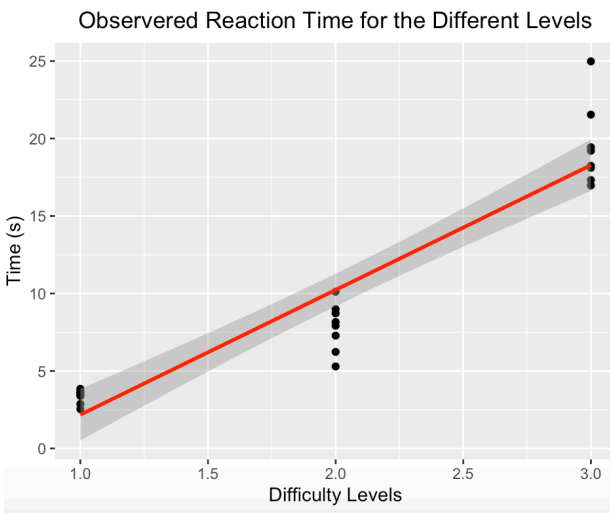

Figure 6: Participant response time in seconds as difficulty increases

The R functions "summary()" and "anova()" were used to obtain a wealth of information, such as the T-test, F-test, R squared, significant values, and residual from the summary, and estimates on how dependent variables with respect to changes in the level of difficulty. Tables 1 and 2 list some of the statistics of the accuracy of participants as well as their response time while the level of difficulty increased:

Table 1: Statistics for the accuracy of participants against level difficulties

Mean	0.7229167
Median	0.75
Range	[0.2, 1.0]
Standard Deviation	0.2608891
T-Value	-2.563

Table 2: Statistics for the response time of participants against level difficulties

Mean	10.22833
Median	8.04
Range	[2.54, 24.98]
Standard Deviation	7.14199
T-Value	-4.381

Estimate Std. Error	-0.15000
Residual standard error	0.2341 on 22 DF
R-Squared	0.23
F-Statistic	6.57 on 1 and 22 DF
p-value	0.01773

Estimate Std. Error	-5.8767
Residual standard error	2.484 on 22 DF
R-Squared	0.8843
F-Statistic	168.2 on 1 and 22 DF
p-value	8.821e-12

To test the correlation between levels and percent, a T-test on the p-value was conducted. To do this, the Pearson correlation formula was used in R, and a p-value of 0.01773 was obtained over a 95% confidence interval. The same test was done to test the correlation between levels and time. This resulted in a p-value of 8.821e-12 over a confidence interval of 95%. To test the level of bias, and skewed results, the following graphs were produced, which help in understanding if the regression lines produced exhibit any bias (see Figures 7 and 8).

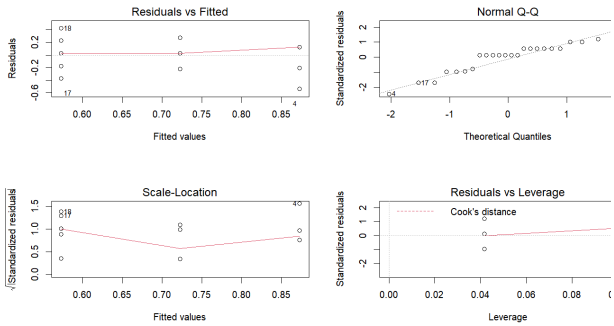

Figure 7: Testing bias on accuracy against levels

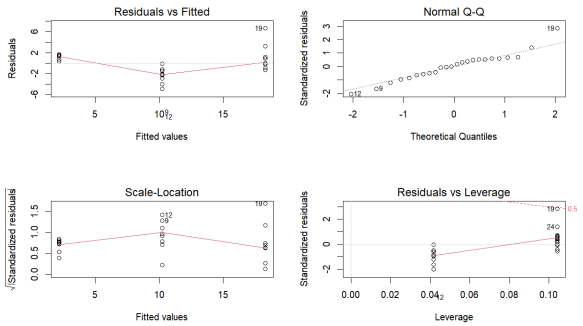

Figure 8: Testing bias on time against levels

5.0 Discussion

The following section will discuss what the team's results mean in terms of the overall research context. This will include an explanation of the implications of the results, the possible relation between the two dependent variables - speed and accuracy, and the benefits and limitations of the experiment.

5.1 Implications of Results

The results of the team's experiment provide numerous findings and insights in terms of the overall research question and context. To reiterate, the purpose of this experiment is to examine the effect of distractions on the speed at which individuals react to a visual stimulus. It was found that across the three stages of the experiment, there was a correlation between the accuracy (Percentages) and the level of difficulty (Different Levels) (ANOVA; $F_{1,22} = 6.5702$, p-value = 0.01773). Further, a correlation between response time (Time) and level difficulty (Levels) was found (ANOVA; $F_{1,22} = 4.374$, p-value = 0.04826). Overall, the results indicate that performance steadily decreased as the complexity of the distractions increased. These results are consistent with other similar studies that demonstrated how distractions impair the performance of individuals being tested [1]. Specifically, in terms of the overall research context, the experiment yielded results that allowed the team to conclusively establish a relationship between accuracy and difficulty level as well as time and difficulty level. As suggested in the results section, the team concludes that the overall trend between accuracy and difficulty level suggests that as the difficulty level of the stage increased, the accuracy level decreased. To determine whether there was indeed a correlation between levels and percentage of accuracy, a P test was conducted. The test examined whether the correlation between levels and accuracy was equal to zero meaning there was no correlation, or if it was not. This two-tail test on a 95% confidence interval resulted in a p-value of 0.01773 therefore, the null hypothesis was rejected and it was determined that there was a correlation between the difficulty of levels and the accuracy of participants. Further, the accuracy percent and difficulty level are somewhat inversely proportional in their relationship (as one variable decreases, the other one increases). Likewise, the overall trend between reaction time and difficulty level shows that as the stages of the experiment increase (difficulty level increases), the response time of the participant increases as well - modelling an almost linear proportional relationship between the two variables. This suggested that there was a correlation between the difficulty level and the speed and confidence at which participants responded. The results of the team's experiment imply that distractions decrease the speed at which an individual reacts to a visual stimulus. Therefore, the experiment confirms the hypothesized relationship the team formed between accuracy, response time, and difficulty level of the distractions.

5.2 Limitations of Experiment

Although the team's study controlled for several factors such as age and gender, there are still several limitations to the overall design of the experiment and the method by which the data was collected. The two main limitations of the experiment were the lack of repeated trials and different experimenters conducting the experiment on the participant. The first limitation of the study was the lack of repeated trials of each difficulty level for each participant. Rather than conducting the experiment for multiple trials, the team decided to test the participant once per each difficulty level. The lack of repeated or multiple trials limits the validity of the results and does not control the experiment fully. Incorporating these repeated trials would increase the reliability of the results of the study because the team could more confidently make conclusions based on the data collected. The second limitation stems from the differing experimenters conducting the stages of the experiment. Since the data collection was performed by several team members, the results might have varied due to the inconsistency in experimenter accuracy, technique, and experience. This limitation had a significant bearing on the reliability of the results because the quantitative data collected - the timing of response time - could have been skewed due to human error or technique & accuracy used by the experimenter.

6.0 Conclusion

The main focus of this study was to examine whether distractions have a direct correlation with the response time at which an individual reacts to visual stimuli, and how the distractions specifically impact a participant's reaction time. Through many statistical methods, the experiment's findings suggest that the accuracy in performance steadily decreases as the difficulty level increases. Further, the study suggests that as the complexity of the distractions increase, the response time increases. These implications are significant in the overall research topic of whether a distraction has the ability to impair motor performance. These results are crucial because they can be applied to the completion of any task and suggest that added distractions will reduce reaction time and decrease accuracy.

References

[1] F. I. M. Craik, “Effects of distraction on memory and cognition: a commentary,” *Frontiers in Psychology*, vol. 5, Jul. 2014, doi: 10.3389/fpsyg.2014.00841.

[2] S. Berti and E. Schröger, “A comparison of auditory and visual distraction effects: behavioral and event-related indices,” *Cognitive Brain Research*, 05-Feb-2001. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0926641000000446#! [Accessed: 12-Apr-2022].

Appendices

Appendix A: Literature Review

Table 3: Brief Literature Review Related to Distraction & Visual Stimuli.

Title	Author(s)	Year	Study Description	Relevant Findings
A Distraction Can Impair or Enhance Motor Performance (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2823087/)	Hemond, Christopher et al.	2010	- Study focuses on the relationship of being distracted while performing a task and examines whether the distraction leads to impaired performance. - Investigates whether the characteristics of the distraction impact motor performance in participants. - Incorporates colour sequencing in the reaction time tasks - where colour and visual cueing were used in each of the two sequences used.	- The addition of distraction is not enough to impair performance but instead the specific process determines if a distraction will impact motor performance in completing a task. - The study found that the level of complexity or amount of distractions does not necessarily always impact motor performance but instead the type of task being completed determines if the distraction will be impactful.
A comparison of auditory and visual distraction effects: behavioral and event-related indices (https://www.sciencedirect.com/science/article/pii/S0926641000000446)	Stefan Berti, Erich Schröger	2001	- Visual changes in an experiment can act as a distraction in a participant's attention especially when the change is unrelated to the task they are completing. - Participants were presented with auditory and visual stimuli for short and long periods of time while being instructed to complete a task.	- The relationship between distracting events and attention is directly impacted by the processing of the distraction. - The paper also found that the retention rate of information is impacted when the environment exhibits an alteration.

Appendix B: Experiment Presentation Slideshow

Below is the experiment presentation slideshow:

https://docs.google.com/presentation/d/1e2pH0FGgQi5r0ntCBF24eRBlRCg6MPvEyJcrxwGgHis/edit?usp=sharing

Appendix C: Data Collection Google Form (Post Experiment)

Below is the Post Data Collection Google Form for Level 1:
https://forms.gle/k4DjFJaCGmWnciPj9

Below is the Post Data Collection Google Form for Level 2:
https://forms.gle/jwn44UcUbvnEBnLcA

Below is the Post Data Collection Google Form for Level 3:
https://forms.gle/cV9ryMx5qz6oepHq9

Appendix D: R Code (Script)

Below is the R code script relevant to the study the team conducted:

```
#R Final project

#Install/Packages
install.packages("ggplot2")
#Download the libraries
library(ggplot2)

#Set working Directory
setwd("~/Downloads")
#Load datasets
Test_data<-read.csv("R_CVS_data.csv", sep = ",", header = T)

####Find the Mean, Median and Standard Deviation of the Independent Variables#####
mean(Test_data$Time,na.rm = TRUE)
mean(Test_data$Percent,na.rm = TRUE)

median(Test_data$Time,na.rm = TRUE)
median(Test_data$Percent,na.rm = TRUE)

sd(Test_data$Time,na.rm = TRUE)
sd(Test_data$Percent,na.rm = TRUE)

##################Levels and Percentages##################
#Graph the data in a Scatterplot
scatter_accuracy <- ggplot(Test_data, aes(Levels, Percent)) +
  geom_point() +
  labs(x = "Difficulty Levels", y = "Percentages (%)", title = "Observered Accuracy for the
Different Levels")+ theme(plot.title = element_text(hjust = 0.5))
```

```
scatter_accuracy

#add a smoothing line to see what the trends look like
#ignoring the span function since it does not impact the line significantly
#created a linear regression line
scatter_accuracy_model<- scatter_accuracy + geom_smooth(method = "lm",colour = "Red")
scatter_accuracy_model

#Correlation/Significance Value (p-test on t-values)
#using pearson because comparing two vector points and not examining ranks
cor.test(Test_data$Levels, Test_data$Percent, method = "pearson")



##Linear regression model
#map the dependent variable onto the independent variable
# since there is limited points and it is a simple model, used linear regression
model_percentage <- lm(Percent ~ Levels, data = Test_data) #creates the model
summary(model_percentage) #shows info about the model created

##ANOVA Test
#estimating the quantitative dependent variable change in relation to the independent variable
anova(model_percentage)
summary(anova(model_percentage))#gives the quartly description with max and min

#to have all 4 graphs on one plot
par(mfrow=c(2,2))
plot(model_percentage)# if you want to see the model individually run this alone
par(mfrow=c(1,1))

####################Levels and Time distribution ##################
```

```
#ScatterPlot
scatter_time <- ggplot(Test_data, aes(Levels, Time)) +
  geom_point() +
  labs(x = "Difficulty Levels", y = "Time (s)", title = "Observered Reaction Time for the Different
Levels") + theme(plot.title = element_text(hjust = 0.5))
scatter_time

#created a linear regression line in the model
scatter_time_model<- scatter_time + geom_smooth(method = "lm", colour = "Red")
scatter_time_model

#Correlation/Significance Value (p-test on t-values)
#using pearson because comparing two vector points and not examining ranks
cor.test(Test_data$Levels, Test_data$Time, method = "pearson")



##Linear regression
model_time = lm(Time ~ Levels, data = Test_data)
summary(model_time)

#ANOVA TEST
anova(model_time)
summary(anova(model_time))#gives the quartly description with max and min

#to have all 4 graphs on one plot
par(mfrow=c(2,2))
plot(model_time)# if you want to see the model individually run this alone
par(mfrow=c(1,1))

#End of Code
```

Appendix E: Excel Sheets with Raw Data Collected (Google Form Results)

Below are the three excel sheets with the responses from the google form.

Excel Sheet - Level 1 Responses:
https://docs.google.com/spreadsheets/d/1TjjVvPOaSauyu-BM6R6le8D_Q8L_lJSpHjpt18auqC0/edit?usp=sharing

Excel Sheet - Level 2 Responses:
https://docs.google.com/spreadsheets/d/1J7H8d9pLx0EoXN-Id2s0zaRwTm26aWtDOOj0xwrI_bM/edit?usp=sharing

Excel Sheet - Level 3 Responses:
https://docs.google.com/spreadsheets/d/18P9bZuvtO6zBY7oTZK94Wwf4DAqBx-bg0es8O1bupbA/edit?usp=sharing