Conducting The Stroop Phenomenon

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March 14th, 2021

Literature Review

The Stroop Phenomenon is used by psychologists and researchers to determine how interferences affect the way the human brain processes information. This phenomenon integrates multiple theories including the selective attention theory, the speed of processing theory, and the theory of automaticity to further make inferences on how attention and processing respond to interference (Ruhl, 2020). This particular experiment is an easy and broad way to look at how the human brain processes information, but even as simple as it is, it gives valuable insight into the brain.

The decision was made to research and conduct this phenomenon because it is exceptionally relevant to society. Throughout an average day, humans have several distractions and types of interference competing for their attention while trying to accomplish tasks. When driving to work, people have to process stoplights, road signs, other cars, music playing, and the feeling of their phone buzz while trying to concentrate on driving. So this phenomenon needs to continue to be researched and developed in order to fully understand what affects the brain's processing on a day-to-day basis.

To conduct this experiment, the methods chosen were measures of central tendency as well as a field experiment. This was the best way to test interference because conducting this in a natural environment would have far too many confound variables and variability. In contrast, conducting this experiment in an artificial environment would be unnecessary because the goal was to receive a natural response from participants rather than having tight control over the experiment which would result in a forced response (McLeod, 2020). Thus, the decision was made to create a setting where participants could partake in the experiment that would create reliability, but also where they could form a natural response. Additionally, the use of measures

of central tendency was the best way to compare results, as it took into consideration any outliers.

Before conducting the experiment, a hypothesis was created that reads as follows: If participants are shown text that has incongruent colors and meanings, then the time in seconds it takes for participants to identify the color of the text will be delayed. After reading research articles about conducting the Stroop Effect test, the conclusion was formed that this experiment was either both reliable and valid or only reliable, as the results were consistent when comparing multiple experiments (Dyer, 1973). Further analyzing, the decision was made that these experiments were valid because researchers developed the experiment in ways that minimized confound variables and were conducted in credible facilities (Gomez, 2019). Because of these factors, it was decided that these experiments were both reliable and valid, so the hypothesis created was based on the results of the experiments that were already conducted.

Methodology

To begin the process of conducting this experiment, informed consent forms and debriefing forms were created to give to the participants to ensure this was an ethical experiment. The informed consent form provided information to the participants regarding the purpose of the experiment, the benefits to the participant, the voluntariness of participation, the option to quit at any time, a general description of the tasks required of participants, assurance of confidentiality, information about how the information will be presented, and the researcher's contact information (McLeod, 2020).

Additionally, participants were given a debriefing form that explained what was being studied and why, real-life implications of the research, the researcher's contact information, and it expressed gratitude for the participant's participation. Moreover, a PowerPoint presentation

was created with five slides, each slide having a series of twenty words. The first slide[a] was for the control group, where the colors and the words were congruent. The next four slides were variations of incongruent colors and words[b], non-primary colors[c], nonsense words[d], and random words[e].

Upon creating the previous documents, ten participants were sought out to participate. The process began with asking high school students and adults if they would like to participate in the experiment. If they agreed to participate, they were handed the informed consent form to ensure they understood their rights as well as what tasks they would be asked to perform. If they agreed to the conditions, they signed the paper for the researcher's safety as well as theirs. The participants were instructed to sit down in front of a computer or a screen presenting the PowerPoint. They were instructed to identify the color and not the word to eliminate any confusion, and they were asked if they were ready to start before each new slide so there was no possible delay in reaction time. Each test for each participant was timed and documented on a piece of paper to later analyze. Once they had completed the experiment, the participants were given their debriefing form, were informed in more detail on what they had just participated in, and were thanked for their time and participation.

Furthermore, looking at the demographics of the participants, three were non-high school adults being the ages of thirty-five years old, forty-two years old, and forty-three years old. Additionally, one freshman in highschool participated, being between the ages of fourteen years old and fifteen years old. Two high school sophomores participated, both being sixteen years old. Two high school juniors participated being between the ages of sixteen years old and seventeen years old. Finally, two high school seniors participated being between the ages of seventeen

years old and eighteen years old. To further look at the demographics of the sample, six of the participants identified as female, while four of the participants identified as male.

Results

The data collected was represented and organized into a chart.[f] [g] Four of the participants were randomly assigned the control group, and their individual times to identify twenty colors with congruent words were 13.39 seconds, 13.79 seconds, 15.96 seconds, and 17.66 seconds. This puts the mean of these times at 15.20 seconds, the median of the times at 14.88 seconds, and it additionally has a standard deviation of approximately 1.73.

Moreover, the experimental group was divided into four categories, but the overall mean for all categories of the experimental group was 15.92 seconds. The first experimental test that was conducted, test 2, was the standard Stroop Effect test where the colors and words were incongruent. The individual times for this test were 14.08 seconds, 16.15 seconds, 17.26 seconds, 19.76 seconds, 19.85 seconds, and 21.37 seconds. The mean of these times was 18.10 seconds, the median was 18.51 seconds, and the standard deviation was approximately 2.5. The next experimental test that was conducted was test 3 which used non-primary colors, and the individual times for this test were 15.62 seconds, 15.90 seconds, 18.09 seconds, 18.11 seconds, 19.32 seconds, and 20.50 seconds. The mean for these test times was 17.92 seconds, the median was 18.10 seconds, and the standard deviation was approximately 1.7. Following test 3, test 4 was conducted which were nonsense words, and the times for this test were 12.42 seconds, 12.71 seconds, 12.82 seconds, 14.79 seconds, 15.03 seconds, and 17.30 seconds. The mean of these test times was 14.20 seconds, the median was 13.81 seconds, and the standard deviation was approximately 1.73. Lastly, test 5 was conducted which were random words, and the individual times for this test were 11.55 seconds, 12.31 seconds, 13.35 seconds, 14.23 seconds, 14.53

seconds, and 15.06 seconds. The mean for these times was 13.50 seconds, the median was 13.79 seconds, and the standard deviation was approximately 1.24.

It is important to note that there were no modes for any of the tests unless times are rounded to the nearest second, and there was no correlation found between age and reaction time.

Discussion

The original hypothesis was if participants are shown text that has incongruent colors and meanings, then the time in seconds it takes for participants to identify the color of the text will be delayed. After conducting this experiment, it can be concluded that the hypothesis was accurate. The control group's mean time was 15.20 seconds, while the two tests that involved incongruence had means of 18.10 seconds and 17.92 seconds. Looking at the mean times alone demonstrates a delay in reaction time when there is incongruence acting as an interference.

Interestingly, it wasn't predicted that the mean times between the tests with incongruence would be particularly close. Test 2 was the standard Stroop Effect test, and it was expected that the reaction time would be delayed because this had the most interference. However, Test 3 used non-primary colors, so instead of using words such as "blue" or "red", colors like "pewter" and "magenta" were used which still had interference, but it wasn't a specific color participants had to identify out loud so it wasn't expected that the participants would slow down as significantly.

Moreover, Test 4 and Test 5 had mean times faster than the control group, being 14.20 seconds and 13.50 seconds. These particular tests had no incongruence, so it was expected that the reaction times were faster than tests that did have incongruence. However, what was interesting to see was that the reaction times for random words were faster than times for nonsense words. It was expected that the nonsense words test reaction times would be the fastest because they had the least amount of interference, as they were not real words. But the mean

time for random words was almost one second faster compared to the mean time for nonsense words.

Setting up this experiment was relatively smooth, and the only real challenge was finding enough people from different grade levels to participate, but that was taken care of quickly with help. Throughout conducting the experiment, there were a few minor bumps and potential confound variables. Beginning with the control group, it was fascinating that participants were hesitant when identifying the colors. This could be because they were explained that they needed to identify the color and not the word, and they expected a form of deception to be used so they were extra careful. It's important to note that this experiment was never testing for accuracy. Accuracy was never brought up in the informed consent form or verbally, but it is believed that participants either assumed accuracy was part of the experiment or they were afraid to mess up. So this was a factor that could have affected the reaction times.

Furthermore, the color "orange" delayed most of the participants because they couldn't identify if it was orange or yellow, as it was a lighter orange[a]. Most of the participants stumbled over it, took a second or two to stare at it, or said the words "I don't know, it's either yellow or orange", which significantly affected the reaction times. Moreover, in one of the slides, there was an occurrence of two colors in a row[e]. Participants either recognized this immediately or they stopped in confusion for a second or two, which also contributed to a delay in the reaction times.

As for the confound variables, the experiments did not all take place in the same location, so the environment could have played a role in either delaying or speeding up the reaction times. Half of the participants went through the experiment in a quiet enclosed room, two of the participants went through the experiment in a loud classroom, and three of the participants went through the experiment in the comfort of their own home. Additionally, noise could have been a

confound variable. One of the participants had his headphones in blasting music, the loud classroom had students talking and music playing, and the TV was on while conducting the experiment for the participants in the comfort of their own home. Noise is another form of interference which could have significantly delayed the reaction times.

If this phenomenon was further studied, there would be expansions on the aspect of age since there weren't any patterns observed in this particular experiment. It would be interesting to try this experiment on children between the ages of six and nine because they may be able to pick up on patterns faster than adults and high school students, which means their reaction time could be much faster. Trying this on even smaller children who might not read or comprehend words as well would also be fascinating to see, especially if the amount of interference would change if the participants do not understand the word. Furthermore, it would be compelling to conduct this experiment on participants who have ADHD, autism, or another condition in which they have a harder time focusing or where certain interferences stand out more. Using this to look at how the brain processes information within these conditions would be enlightening, and it would give society a better understanding of the participants.

All things considered, the Stroop Phenomenon is a great way to easily look into the processing of the brain from the raw responses of humans. It gives a broad idea that different types of interference can delay processing which can lead researchers to continue to expand on and develop these ideas. Further research may even be able to enlighten us on brain decay as well as brain conditions that can potentially advance us as a society even further. So something so simple as identifying colors can give researchers insight into one of the most important human organs, which can expand our knowledge on the way we function.

References

Dyer, F. (1973). The Stroop phenomenon and its use in the study of perceptual, cognitive, and response processes. Memory & Cognition, 1(2), 106-120. doi: 10.3758/bf03198078

The author, Frederick Dyer, has researched experiments over the Stroop phenomenon analyzing different variations and variables to determine how the brain processes information and what interferences get in the way, additionally determining any limitations in the experiments. To determine any interferences, all researchers in every variance of any experiment measured the amount of time it took participants to name a color with incongruent text, in milliseconds, to see how the brain processes information with any interferences. Variances include the traditional naming of a color with an incongruent word, sorting cards into different piles with different colors and incongruent words, auditory tests, naming colors with nonsense or random words, and different sequencing patterns. Throughout these experiments, it has been noted specific limitations such as the fact that because people get used to thinking this way and participating in experiments over several days, and it has been confirmed that reaction times become less delayed. Additionally, certain experiments weren't set up accurately and several failed experiments did not conclude the way researched thought it was going to end such as the auditory experiments which did not affect the reaction time of participants. In analyzing all of these experiments, researchers can confirm there is a definite reaction delay on the traditional form of the Stroop phenomenon where participants name a color with an incongruent word. The reaction delay has been recorded as an average of 50 milliseconds, which demonstrates that interferences cause a delay in the processing of visual information. It is important to note this is a research paper, reviewed by other researchers and scientists, of good quality and high credibility.

Gomez, Gabriela. (2019). Replicating the Stroop Effect. doi: 10.13140/RG.2.2.16499.37926.

This was an experiment done by Gabriela Gomez at the Florida Atlantic University with the intent of replicating Stroop's original experiment. This research paper is highly credible and of good quality. Gomez set up the basic idea of the experiment, with the only difference from Stroop's original experiment being that the Stroop tests were on computers. It's important to note that they were pressing down on keys, which could add to more inaccuracies because they can't 'backtrack' or change their answers. Similar to Stroop's experiment, there were different variations in the independent variable, using both congruent and incongruent text, as well as using different combinations in sequences. The results did replicate what Stroop originally found, that when incongruent text is used, there are more inaccuracies as well as more of a delay on the reaction time. This has confirmed what researchers believe that automatic reading processes do interfere with information because humans can process words faster than they can identify colors.

McLeod, S. (2021). Research Methods | Simply Psychology. Retrieved 15 March 2021, from https://www.simplypsychology.org/research-methods.html

Ruhl, C. (2021). Stroop Effect | Simply Psychology. Retrieved 12 February 2021, from https://www.simplypsychology.org/stroop-effect.html

In this article, the initial intentions and the further development of the research over the years on the Stroop Effect is discussed by author Charlotte Ruhl. Though this is not a peer-reviewed article, it is still highly credible and of good quality, as the author is a member of Harvard University as a social cognition researcher. The Stroop phenomenon is described as a look into the brain's automatic and controlled processing of information when interferences occur such as incongruent stimuli and the effect of these variables on the reaction time of people participating

in this experiment. Research has confirmed when participants are interacting with incongruent stimuli, it causes a delay on the reaction time. In the initial study Stroop created, he was trying to determine how different interferences affect reaction time, so his study was the traditional route of naming a color while reading an incongruent word which resulted in him finding there was a 47-second delay compared to just reading words in black text. But this study has since progressed and now uses different variations such as naming the color of emotion words, using threat words with panic disorder and OCD patients, the idea of processing of numerosity and duration, digit and numerosity processing, and central vs. peripheral letter identification. Researchers have also looked into different theories and brain processes such as Selective Attention Theory, Speed of Processing Theory, Automaticity, Parallel Distributed Processing, Semantic Interference, Semantic Facilitation, and Stroop Synchrony. This has further led researchers to look into the parts of the brain, finding the Dorsolateral Prefrontal Cortex and Anterior Cingulate Cortex light up on MRI scans while conducting this experiment, both dealing with memory, executive functioning, and selecting responses. This confirms the Stroop effect impacts the processing of the brain through interference.

Appendix

[a] Figure 1

Control Slide

Note: Notice the light orange.

[b] Figure 2

Standard Stroop Test

[c] Figure 3

Non-Primary Colors

[d] Figure 4

Nonsense Words

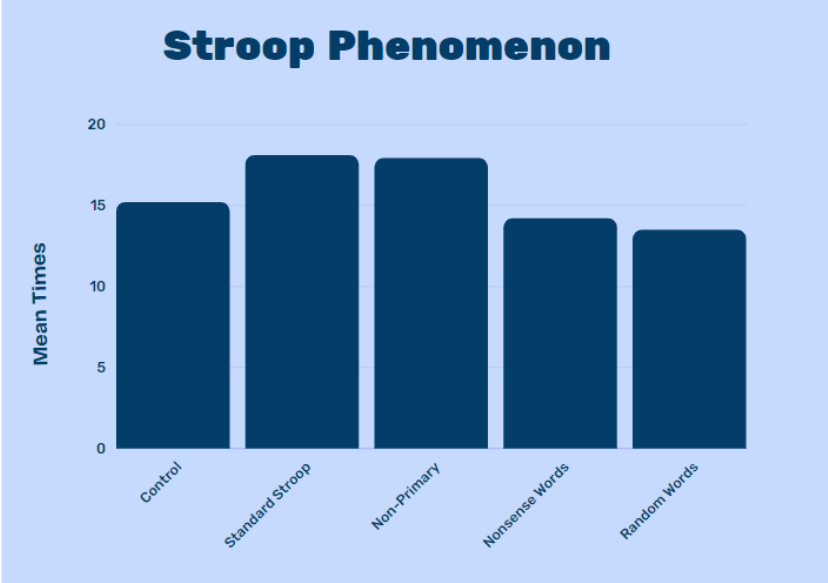
[e] Figure 5

Random Words

Note: Notice the occurrence of blue twice in a row.

[f] Figure 6

Graph of All Mean Times for Each Test



[g] Figure 7

Chart of All Collected Test Times

Collected Data
Stroop Effect

*N/A means they did not participate in the specific test because of the idea of random assignments. Some of them only did the control test, and others only did the experimental tests.

Participant	Age Range	Test 1 (Control)	Test 2 (Standard Stroop Effect Test)	Test 3 (Peculiar Words)	Test 4 (Gibberish)	Test 5 (Random Words)
1 Control	Sophomore (15-16 Years Old)	13.79 Seconds	N/A	N/A	N/A	N/A
2 Experimental	Adult (35-45 Years Old)	N/A	19.76 Seconds	18.09 Seconds	12.42 Seconds	12.31 Seconds
3 Control	Adult (35-45 Years Old)	15.96 Seconds	N/A	N/A	N/A	N/A
4 Experimental	Senior (17-18 Years Old)	N/A	14.08 Seconds	15.90 Seconds	12.71 Seconds	11.55 Seconds
5 Experimental	Adult (25-35 Years Old)	N/A	19.85 Seconds	19.32 Seconds	17.30 Seconds	13.35 Seconds
6 Experimental	Junior (16-17 Years Old)	N/A	21.37 Seconds	15.62 Seconds	14.79 Seconds	14.23 Seconds
7 Control	Junior (16-17 Years Old)	13.39 Seconds	N/A	N/A	N/A	N/A
8 Control	Sophomore (15-16 Years Old)	17.66 Seconds	N/A	N/A	N/A	N/A
9 Experimental	Senior (17-18 Years Old)	N/A	16.15 Seconds	18.11 Seconds	15.03 Seconds	15.06 Seconds
10 Experimental	Freshman (14-15 Years Old)	N/A	17.26 Seconds	20.50 Seconds	12.82 Seconds	14.53 Seconds