

Advanced Stroop Effect
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Abstract

This study further examined the well-known process of the Stroop effect and experiment by J.R. Stroop through an advanced Stroop task. There were 23 participants who completed 4 conditions testing for reaction and accuracy. For each condition the participants were asked to report the color of the font. One condition presented a string of Xs that were colored either purple, orange, or green. Another condition presented a word that spelled out one of the three colors, but was in a font colored different than that of what the text spelled. Yet another condition presented one of the three color words, with the first and last letters in the correct positions and the middle scrambled. The color of the font matched what the word was spelling. The final condition presented one of the three words with the letters in all random positions. The font color did not match the color the word was spelling out. We found a significant difference for reaction time and accuracy between conditions. The Stroop task teaches us that when reading becomes an automatic process, simple tasks such as identifying the font color of a word that spells a color can be very difficult.

Advanced Stroop Effect

Most people begin to learn to read at a young age. At these beginning stages, reading is effortful, requiring conscious attempts at sounding out each letter of each word. As people repeat and practice reading skills, they eventually learn to read without trying. Minimal conscious effort must be put into the task of reading. When a cognitive task, such as reading, becomes so practiced that it does not require conscious effort to be completed, the task is considered to be automatized (Francis, Neath, & VanHorn, 2008). A study was conducted by J.R. Stroop (1935) in order to test the effects of automaticity, specifically on reading. In one condition, Stroop presented his participants with 100 words, each of which spelled out a color, but the ink of the word was a different color than what the word spelled. The participants were asked to report the color of the ink the word was presented in. Reaction times were recorded. In addition, he showed participants 100 sets of squares, each presented in certain colors, and asked them to report these colors. Again the reaction times were recorded. Stroop found that it took an average of 47 total seconds longer for participants to get through the condition where word names were spelled out. Based on this study and these results, we get Stroop tasks and the Stroop Effect. When the participant is asked to report the color of a word that spells out a color different from the color of the ink/font, they are completing a Stroop task. The trend to have longer reaction times when words and word colors do not match is known as the Stroop Effect. (Stroop, 1935)

Many other studies have been conducted in response to Stroop's original study and findings. One such study was completed by MacLeod and Dunbar (1988), where the researchers

looked at the possibility of a continuum of automaticity. Participants went through 4 phases of learning, in which they essentially learned to associate colors with shapes. For example, in one of the phases, the participants might have learned that when they saw a square they were to think of the color red. These phases were taught for 3 different experimental groups, the first group being taught for 2 hours, the second group being taught for 5 hours, and the third group being taught for 20 hours. The results showed that on average, the more time that was spent on the training, the faster the reaction times of the task. The researchers believed that their findings supported the idea of a continuum of automaticity. This means that there is not just one level of automaticity. Cognitive functions, based on the level of repetition and practice they receive, can vary as to how automatic they are. For example, for a 2nd grader, reading is moderately automatic, whereas, for a college junior, reading is very automatic.

Based on these studies and findings, we want to know if there is a point where the spelling of the word in a Stroop task is so jumbled that it does not interfere with our ability to report the color of the word. Is there a point where the word is so jumbled that it is off of our continuum of automaticity? We expect to find that the more jumbled the words are, the quicker the reaction times, because the process of reading the jumbled word will not be automatic, as we are not required to read jumbled words. Therefore, we will be able to ignore the jumbled words better than the more correct words when reporting the color of the word.

Method

Participants

There were 22 participants from a Midwestern college. Participants were between the ages of 19 and 22. No one reported a color deficiency. Participants were obtained through a sign-up sheet.

Equipment

This study was completed on Gateway Computers, model E4300. The monitor resolution was 1024 by 786 pixels. The browser was Internet Explorer 8, and the program was called “Stroop Experiment” from the Cognitive Laboratory Experiments website (Krantz, n.d.). The program was written Java. Participants were also given a spread sheet in which they filled in their reaction times and accuracy.

Stimuli

There were 4 different stimuli for this study. In one condition the stimulus was a string of X's, which was the control condition. Another condition had incongruent words, meaning that the color that the word spelled out did not match the actual color of the word. For example, if the word said orange, but the font color was green then this would be considered incongruent. Also, there was a condition that had the first and last letters in the right places, but the middle letters were all scrambled, and the color that the word was spelling matched the color of the font. So, the spelling might be “oanrge” and then the color of the word would be orange. The fourth condition had all of the letters in random positions and the word was colored a different color than the word. So, if the word was “rngeoa” then the color of the word might be green. Each of the stimuli either spelled or was presented in one of 3 colors: green, orange, or purple. The entire font was size 16 and written in sans serif, so it was without any fancy lettering. All of the words were presented in the center of the screen.

Procedure

The study was done in the psychology computer laboratory at Hanover College. Each of the participants signed an informed consent form before starting the study. Participants were told to go as fast as they could. To begin, participant pressed the space bar. A word appeared in the middle of the screen. The participants were to identify the color of the word. This could be done by striking the corresponding key on the keyboard, or by using the computer mouse to click on the buttons (which had a color on them) at the bottom of the screen. Immediately after the participant responded, the next trial began, with a new word appearing instantly. Each word appeared on the screen one at a time. After each condition the participants recorded their average reaction time and accuracy on the spread sheet given to them by the researchers. The averages were found by averaging the 25 trials within each individual condition. There were 4 conditions in all (Xs, incongruent, middle random congruent, and all random incongruent). The independent variable was the stimulus type (the 4 conditions) and the dependent variables were the reaction times and accuracy.

Results

We expect to find that the more jumbled the words the quicker the reaction times. We excluded one of our conditions, the middle random congruent condition, when interpreting our data, because it was not pertinent to our study. The words needed to be incongruent with the color of the font instead of congruent. This was a researcher error in instructing the participants which conditions to do. Two one-way ANOVAs were used to test for differences in reaction times and accuracy across conditions. We found that reaction times differed significantly between conditions ($F(3, 19)=10.48, p < .001$), such that the X condition was the fastest (M

=814.89), the all random condition was the second fastest ($M=846.26$), and the incongruent condition was the slowest ($M=1062.61$), as seen in Figure 1. In addition, there was a significant difference of accuracy between conditions ($F(3, 19)=4.06, p=.02$), such that the all random condition was the most accurate ($M=.995$), the X condition was the second most accurate ($M=.98$), and the incongruent condition was the least accurate ($M=.97$).

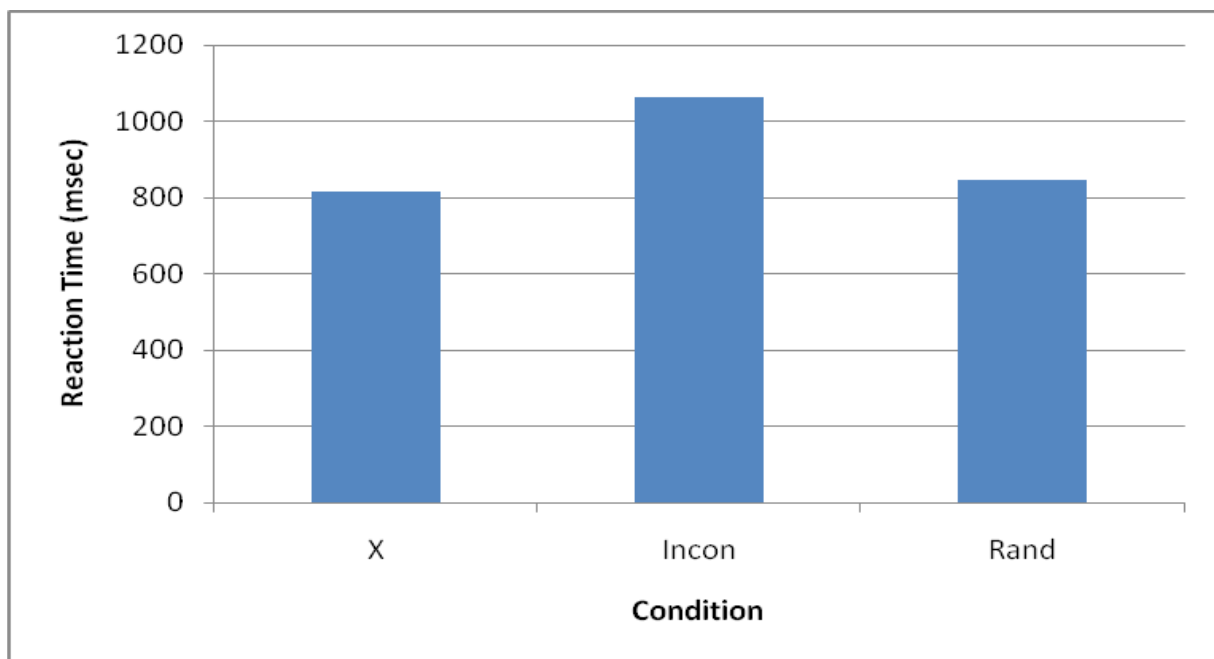


Figure 1. Average reaction times across conditions.

Discussion

Our hypothesis was that reaction times would be faster the more jumbled the words. Our results supported this hypothesis, as the all random condition, which had the letters of the words all jumbled, was the second fastest in reaction times, only behind the control condition. The incongruent words condition, which had the color words spelled correctly and the font in a different color than what the word spelled, was the slowest. These results differed significantly. This could be due to the idea of a continuum of automaticity, as was found in MacLeod and

Dunbar's (1988) research. We do not get a lot of practice reading words that are spelled incorrectly, therefore they do not become automatized. Because the words were so jumbled in the all random condition, we were not automatically reading them, and so the words were not interfering with our ability to report the color of the word. On the other hand, we have been seeing the words orange, purple, and green since we first started reading, so are able to read them automatically now. This is why it takes longer for participants to report the color of the word, because the word itself gets in the way.

There was also a significant difference between the conditions for accuracy, as the all random condition was the most accurate, the control condition was the second most accurate, and the incongruent condition was the least accurate. Although we did not expect to find a difference in accuracy between conditions, these findings do support our hypothesis because the fast conditions have the best accuracy, essentially meaning that there is no speed-accuracy tradeoff in this study.

Upon evaluation of results, we realized that we made a mistake, as mentioned above, in telling the participants which conditions to do. As described in the methods section, we had the participants do a "middle random congruent" condition, meaning that the middle of the words were jumbled and that the color and the word matched. However, we meant to have the participants do the middle random incongruent condition, so that the colors and words would not match. Because the words and colors were the same, the data from this condition was not relevant to our study, thus it was taken out of the results.

In addition, we had to take one female participant out of the data. She had an accuracy of .16 on one of the conditions. She told the researchers that she started the condition by

responding to the word itself, and then half way through the condition realized that she was supposed to respond to the color of the word, so she switched. She said she thought that she should do the condition over again, but decided not to. We did not want her admitted error to skew our results, therefore her data was removed.

There were several parts of the study that could have been changed in order to help us get better results. First, there were many computers that froze at different points throughout the study. This could have impacted our results, such that the participants might have gotten stressed out and frustrated by the computers. In addition, as other participants finished before the people on the frozen computers, this could have added to the stress, which might have made participants go faster and also less accurate.

Another issue with our study was that we did not ask about the gender of our participants, which has been shown to make a difference, as seen in a study by Silvia von Kluge (1992). The study found that when speed is stressed on a Stroop task, women and men tend to perform at equal speeds, but women are more accurate. Had we asked for the gender of our participants, we could have seen a difference in the accuracy between the genders. Also, we could have checked for a difference in reaction times between genders, but this study suggests that we would not find a difference.

Having a larger sample size with more of a variety of ages would have had its own effects on the results. As people get older, their automaticity for cognitive functions fades, thus their reaction times would have been faster. In addition, if the participants were of different educational levels, we would have seen a faster fading of cognitive functions in the older participants of lower education. (Van der Elst, Van Boxtel, Van Breukelen, & Jolles, 2006)

Thus, our results cannot be applied to people of all cultures and age ranges, but to this specific population.

The results of this study are important in looking at how children learn, specifically at how they learn to read. When students first begin to learn to read, the task is not automatic. It requires thought and effort. The students cannot focus as much on what is being read, mostly on the process of reading. As students get older, reading becomes easier and more automatic. They are able to read without paying attention to what is read. Teachers need to be aware of this, and the information about automaticity, and strive for a more conscious and attentive way of reading. This is not to say that automaticity is bad, or that being able to read automatically is wrong, but it is good to be more aware when performing such tasks.

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