Stroop interference and the effect on automaticity in serial-verbal responses

Elizabeth Ashkinazi

Department of Psychology City University of New York at Hunter College

PSYCH 250: Experimental Psychology

December 3rd, 2020

Abstract

Information-processing is often done automatically and non-consciously. The Stroop Effect is a measure of automaticity as represented by response time. It is the finding that people experience delays in responding to incongruent stimuli. Our experiment was a replication of the original Stroop study, where participants responded with the correct color of a word significantly more slowly and more inaccurately during Incongruent trials (where color words and the word color are unaligned) as opposed to Congruent trials (Stroop, 1935). This study explored this phenomenon once more. We sought to demonstrate the automaticity of information processing using the Stroop Test. Twenty participants were instructed to take a demo-version of the Stroop test online. Results showed that the incongruent condition of the Stoop test took significantly longer to complete than the congruent condition regardless of test orientation. Further research is needed to explore the variables of gender, age, and impulsivity. The potential for a future Stroop-related ADHD study in which the Stroop Effect is measured for individuals with ADHD could also provide insight into the ideas of inhibitory processes and automaticity.

Keywords: Stroop Effect, automaticity, information-processing, color, words, incongruent, congruent

Stroop interference and the effect on automaticity in serial-verbal responses

The automaticity of information-processing and attention is reflected in many human behaviors. These unconscious behaviors involve the presence of stimuli which may produce these behaviors, such as the blinking of an eye when air is blown, or the Babinski reflex. Similarly, some learned behaviors are also thought to be automatic, such as reading and word identification (Besner et al., 1997). This is because of an inability to process all the information we intake through our senses. As a result, selective, goal-directed behavior takes precedence over irrelevant information in the information-processing system (Purmann & Pollman, 2015).

The Stroop Effect is the finding that people respond with the correct color of a word significantly more slowly and more inaccurately during Incongruent trials, where color words and the word color are unaligned (Stroop, 1935). Reading color words, with each word naming a color unlike the color of the ink, was not significantly affected, as response times only showed a 5 percent increase. This points to the idea that some level of automaticity is present in reading. Automaticity is rapid behavior that is not carried out with intent. It is fostered through practice and repetition (Liefooghe et al., 2019). These results may also point to a difference in familiarity or "training" with reading words as opposed to naming colors, because of the highly associative nature of colors. Research on the Stroop Effect by Besner has shown that single-colored letters produced a significantly smaller Stroop effect than did the all-colored-words, and that the color-words created a more pronounced Stroop effect than their pseudohomophonic counterparts (i.e., "blue" and "bloo") (Besner et al., 1997). In addition, a study conducted on child musicians and the presentation of musical notes (which were labeled) and Congruent/Incongruent placement on a staff reflected similar findings: reaction times were slower when the placement of the note did not align with the labeled note (Grégoire et al., 2019).

In our research, we sought to demonstrate the automaticity of information processing using the Stroop Test. It is hypothesized that the incongruent condition of the Stoop test will take significantly longer to complete than the congruent condition regardless of test orientation.

Method

Participants

Twenty participants in a virtual Experimental Psychology class setting were asked to complete a demo version of the Stroop test online. All participants were college students and were selected by way of convenience sampling, with the sample being derived from a class setting. All participants were Psychology majors at Hunter College. Participant ages ranged from young adult to adult. Both males and females participated in the study.

Materials

Participants were asked to complete a demo of an online Stroop test. The Stroop test was located at the domain https://www.psytoolkit.org/lessons/stroop.html. The test was taken on personal computers and laptops (Apple, HP, Dell, etc.).

Procedure

Participants were provided with the link to the Stroop test by the instructor. Participants were then instructed to take the test and to report the results for Congruent Words and Incongruent Words in the Zoom chat box. Participants were advised to run through the test trial and to use the keyboard to make responses. The screen displayed a color word and the color of the displayed word. Congruent Words were color words that aligned with the color of the word, and Incongruent Words were color words that did not align with the color of the word. The letter "R" was denoted to mean the color Red, "G" for Green, "B" for Blue, and "Y" for Yellow. Participants were advised to type these letters to represent their responses to the color of the ink

only. Results were displayed in the form of milliseconds (ms) for both the Congruent and Incongruent trials. The Stroop effect was represented in milliseconds as a difference between the Incongruent and Congruent trials, respectively. Results for all 20 participants were compiled.

Results

Participant means were computed for both Congruent (M = 845.75, SD = 244.52) and Incongruent trials (M = 957.5, SD = 242.94). (Table 1). Participant means for Incongruent trials were higher than for Congruent trials for response times, in milliseconds (Figure 1).

Researchers ran a paired samples t-test to determine if there was a significant difference between Congruent and Incongruent trial response times. Response times for Incongruent trials (M = 957.5) were significantly higher than response times for Congruent trials (M = 845.75) $t(19) = -5.56$, $p < .01$. (Table 2). Our hypothesis was supported.

Discussion

Our hypothesis that the incongruent condition of the Stoop test will take significantly longer to complete than the congruent condition regardless of test orientation was supported. Response times for Incongruent trials were significantly higher than response times for Congruent trials. Moreover, there is an observed relationship between congruence and response time -- Incongruent conditions yield higher response times, and vice-versa, pointing to a higher Stroop Effect and the need for greater attentiveness towards naming colors than simply naming the words. Automaticity is also thought to be reduced, because more thought is devoted to naming the color as opposed to the word.

Similar findings are reflected in the original Stroop experiment (1935), where significant reaction time differences were observed between Congruent and Incongruent trials. There was a 74.3 percent increase in reaction time for naming color words. Our findings were consistent with

those of the Stroop experiment, presumably because more attention is necessary to naming color-words than simply reading words, and automaticity is reduced.

Findings reflected in research on child musicians indicated a Reverse Musical Stroop Effect (RMSE), where participants were asked to name notes (with note names being written inside the notes) on a staff. It was hypothesized that this process would take longer when the note name written inside the note did not correspond to its proper location on a staff. Findings were in support of this idea, as participants took a significantly longer time to name notes under the Incongruent conditions (Grégoire et al., 2019). These findings mirror our own in that automaticity is reduced when Incongruence is present. Musically-trained individuals are able to pinpoint where a note should lie on a staff and the name that corresponds to the note (a practice that involves reading), so it makes sense to infer that doing so under Incongruent conditions would yield less automaticity and accuracy.

Research conducted by Besner indicated that single-colored letter conditions eliminated the Stroop Effect altogether, and words yielded a larger Stroop effect than did the pseudohomophones (“blue” as “bloo”, etc.) (Besner et al., 1997). In part, these findings contradicted those of our own and the original Stroop experiment, indicating that the automatic reading hypothesis that is presumed to be true is flawed or too strong. The single-letter condition should theoretically have produced as much of a Stroop Effect as a whole Incongruently-colored word. Perhaps this is because of factors like mental set, a term which refers to the brain's propensity to solve problems in a way that is familiar. This is reflected in perception, as individuals are able to easily reconcile one colored-letter as opposed to a whole word. This phenomenon could also explain the smaller Stroop effect for pseudohomophones, but in the opposite way. Since the brain is unfamiliar with pseudohomophones, it would take a longer time

to decode the meaning of the word after reading it as opposed to the color of the word, thereby yielding more accurate and faster results for color-identification.

Within our study, one possible limitation that arose was the inability to ensure the standardization of testing conditions. Because of the nature of our data collection, testing conditions varied between participants. There was no way to account for and limit distractions, and the various types of computers and their keyboards may have played a role in altering results. In addition, there was no way to ensure that participants did not repeat trials in order to get a better result. Participants were instructed to only take the test once, but if one were to take the test twice or even multiple times, carryover "training" effects and familiarity with the task at hand would likely be present, thereby skewing results. In addition, familiarity with one's keyboard and muscle memory may also play a role in determining reaction speed. Some people may be quicker at responding to trials than others because they are more acclimated to typing. Different response times might be yielded for people with sensorimotor impairments and people who have slower typing speeds in general.

Further research possibilities could include the exploration of variables like gender and age. Running statistical analyses on both genders would help to see if there is a meaningful difference between reaction times. Because inhibitory processes and sensorimotor capabilities are involved in taking the test, it would be interesting to see if there is a distinction between males and females in these areas (with one gender displaying more impulsivity or being better-coordinated, etc). The same could be done for the variable of age, where meaningful differences between age groups can be gleaned depending on elements like impulse control, sensorimotor coordination, and "training", as well as the flexibility and plasticity required to become trained. Some elderly folks still find it difficult to use electronic devices despite being

taught how to use them, therefore training might entail a greater amount of tedium than it likely would for someone who has surpassed the technological learning-curve. This idea of impulsivity could also be explored in a future Stroop-related ADHD study, where the Stroop Effect is measured for individuals with ADHD. Because inhibitory processes are involved in picking the correct answer and reducing automaticity, and because people with ADHD have impaired executive function, a significant difference between those with ADHD and those without it could be reflected in the data.

References

Besner, D., Stolz, J. A., & Boutilier, C. (1997). The Stroop effect and the myth of automaticity. Psychonomic Bulletin & Review, 4(2), 221-225. https://doi.org/10.3758/bf03209396

Grégoire, L., Poulin-Charronnat, B., & Perruchet, P. (2019). Stroop interference depends also on the level of automaticity of the to-be-interfered process. Acta Psychologica, 197, 143-152. https://doi.org/10.1016/j.actpsy.2019.05.013

Liefooghe, B., Hughes, S., Schmidt, J. R., & De Houwer, J. (2020). Stroop-like effects of derived stimulus–stimulus relations. Journal of Experimental Psychology: Learning, Memory, and Cognition, 46(2), 327-349. https://doi.org/10.1037/xlm0000724

Purmann, S., & Pollmann, S. (2015). Adaptation to recent conflict in the classical color-word Stroop-task mainly involves facilitation of processing of task-relevant information. Frontiers in Human Neuroscience, 9. https://doi.org/10.3389/fnhum.2015.00088

Stroop, J. R. (1935). Studies of Interference in Serial Verbal Reactions. Classics in the History of Psychology. https://psychclassics.yorku.ca/Stroop/

Table 1

Average response time for Congruent and Incongruent conditions in milliseconds

	N	*M*	*SD*	SE
Congruent	20	845.75	244.52	54.68
Incongruent	20	957.5	242.94	54.32

Table 2

T-test results of Congruent - Incongruent trial response times

Measure 1	Measure 2	*t*	df	p
Congruent	Incongruent	-5.56	19	<.001

Figure 1

Comparison of Congruent-Incongruent response times