Interfering With Interference:

The Effect of Frustration on Automaticity and Attention in the Stroop Effect

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Abstract

This study was designed to examine how the cognitive functions of attention and automaticity, as identified in the Stroop Effect phenomenon, are impacted by frustration. It was hypothesized that being in a frustrated state would inhibit attentional override of reading automaticity, thereby exaggerating the Stroop Effect. To test this, N = 24 participants' completed the Stroop Task. Of these participants, N = 13 were randomly assigned to a "frustration" condition induced by a "malfunctioning" computer program that prohibited them from successfully completing a simple memory task. The mean size of the frustrated group's Stroop Effect was compared to that of the control group. While no significant difference was found between the mean Stroop Effects for each group, a significant interaction, $p < .088$ at alpha level = .1, between the frustration and Stroop Task condition indicated that frustration tended to reduce the size of the Stroop Effect. In other words, participants under frustration significantly outperform non-frustrated participants on the Stroop Task which runs counter to our hypothesis. The implications of these results are discussed in terms of attention and automaticity in the Stroop Effect and future directions are suggested.

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Barker (1938) generated considerable interest among psychologists in understanding how various cognitive abilities are affected by frustration with the publication of his article *The Effect of Frustration Upon Cognitive Ability*. Dollard et al. (1939) developed an operational definition of frustration, defined as "an interference with the occurrence of an instigated goal-response at its proper time in the behavior sequence" (Dollard, Doob, Miller, Mowrer & Sears, 1939). As computers became popularized and adopted into the workplace (NTIA, 2001) the phenomenon of *computer frustration* became a valid psychological object of study (Ceaparu, Lazar, Bessiere, Robinson, Shneiderman, 2004). This study used a timed-diary methodology which prompted computer users, at randomly selected times throughout the day, to record their current experience with said computers. Nearly one-third to one-half of these entries documented frustrating experiences with computers. (Ceaparu, Lazar, Bessiere, Robinson, Shneiderman, 2004). Computers were frequently experienced as frustrating for a variety of reasons, and many of the sources of frustration nicely fit Dollard et al. (1939) abovementioned definition of frustration. A malfunction in a computer program or the participants inability to find certain icons and features, for example, prevented a simple instigated goal from being completed at the time deemed necessary for its completion. (Ceaparu, Lazar, Bessiere, Robinson, Shneiderman, 2004). It seems reasonable to broaden the scope of Barker's work on the effects of frustration on cognitive abilities to include frustration generated by computers. Such a task also appears highly relevant in light of the fact that many measures of cognitive abilities are increasingly conducted online with computerized methodology. If frustration does impact cognitive abilities, and if persons experience frustration while using computers often, it is plausible that computerized tests of cognitive abilities may not be measuring cognitive performance in a vacuum, but rather cognitive performance under frustration. If, indeed, this is the case than it is important to have a working understanding of how computer-generated frustration affects performance on computerized tests of cognitive abilities. To rephrase, If computers generate frustrating experiences, and if psychological experiments measuring cognitive abilities increasingly transition from physical tests to online computerized tests, it becomes reasonable to ask what effects does computer-generated frustration hold for the performance of cognitive abilities. To reduce this general question to a specific testable research question, this study aims to only examine the cognitive ability of automatic processing and attentional override of automatic processing as measured by the Stroop Effect.

The Stroop effect was originally described in research published by J.R. Stroop (1935) around the same time Barker (1938) began investigating frustration. Though relatively under-appreciated in its own time, it has since become one of the most prolifically studied phenomena in psychological research (MacLeod 1991). MacLeod (1991) attributes the appeal of the phenomenon in research to its ability to demonstrate some very basic, elemental cognitive processes concerning automaticity's effects on attention.

In his study, Stroop (1935) observed that the presentation of a stimulus with incongruent features would slow a participant's reaction time in identifying one of those features when that identification was practiced to the point of automaticity. Specifically, Stroop (1935) utilized color names that had been printed with ink in colors other than that which the word named, so that the word "green" might be printed in purple ink. When participants were asked to identify the color of the ink in this condition their reaction times were significantly delayed compared to when they completed the same task on words printed in congruently colored inks. This effect was also observed, if less dramatically, when the reaction time of participants who were asked to read the word when it was printed in an incongruent ink color was compared to when those participants were asked to read the word printed in black ink.

Stroop's observation of significantly increased reaction times in these incongruent situations effectively demonstrates the phenomenon of cognitive interference. Cognitive interference occurs when the processing of an automatic function happens quicker and so blocks the processing of a function that is less automatic. As noted by Solso, Maclin, and Maclin (2008) in their book, automatic processes are those that have been practiced to the extent that they can occur without our attention. Reading and color naming are examples of automatic processes. The fact that identifying the color in an incongruent scenario takes longer than reading the word suggests that the latter is more automatic than the former. Essentially, we automatically read the color name before our attention can fixate on the stimulus to decide which of its aspects are most important. Therefore, in the Stroop effect, a participant must override the faster reading process before they can begin to attend to the process of identifying the color. The faster reading process "interferes" with the slower "color identification" process. Attention must "catch up" to the stimulus processing and stop the behavior output. MacLeod (1991) identifies this explanation of the Stroop effect as the "bottleneck explanation," which means that there is only so much room for processing certain mental pathways, and the data that arrives first must be attended to before any other data can be attended to.

In addition to being linked to numerous attentional disorders (Amsel, 1990), frustration has been thought to constrict attention (Knott, 1971). This leads the researchers to believe that frustrated participants will perform worse on the Stroop task, have larger Stroop size effects as measured by a slower reaction time in the incongruent condition, than non-frustrated participants.

Method

Participants

Demographic data of participants was gathered through self report. Twenty-four undergraduates (*N* = 8 female) volunteered to participate in this experiment, four of whom received extra credit in an introductory psychology course as incentive to participate. Their ages ranged from 19 to 22. All participants reported normal or corrected normal vision that in no way interfered with their ability to identify any of the stimuli presented.

Stimuli

The present experiment involves three stimulus phases that vary between the control and experimental groups in only the first of these phases. The conditions of the second and third stimuli phases reflect within subject variables. Phase one is a working memory task and phases two and three are conditions of the Stroop Task.

The stimulus in phase one is presented in white, size 24 font in the middle of a 306 X 250 millimeter rectangular screen after the removal of a fixation mark. It consists of a series of five random, one to two syllable words displayed individually for five seconds each. At the conclusion of this presentation, a word-selection box is displayed for twelve seconds at the top of the screen. It displays the words presented in the previous list along with five distracters in a 2 X 5 arrangement so that the participant can select the words recalled from the set presented. In the frustration condition, there is a forced delay of three seconds between each word selected so that it becomes impossible to select each of the five total words recalled as selecting each word after the delay would require 15 seconds where only 12 are available. At the conclusion of the twelve seconds, the selection-box is removed and a new fixation mark indicates the beginning of the next trial.

The stimuli in phases two and three reflect two Stroop Task conditions. In phase two, the control condition stimuli consists of a series of individually presented string of four Xs (XXXX) that appeared in one of four possible colors. The colors that all stimuli appeared in varied between red, green, yellow, and blue. Phase three, the "Incongruent words" condition, consisted of color names presented in colors different from those the word was naming, so that the word "green" might appear in yellow letters. The words were presented in size 24 font in the middle of a 306 X 250 millimeter rectangular screen after the removal of a fixation mark. Participant's responded to the stimuli using a display of four buttons corresponding to each of the possible colors that remained at the bottom of the screen.

Equipment

The equipment used for this experiment included a Gateway computer (model code E4300) with an Intel Pentium 4 Processor that ran with the Microsoft Windows XP operating system. This was used to run both the Working Memory and Stroop Effect experiment software from which the experiment was operated (Krantz, 2008), which are based on the Standard Edition Java Version 1.3 platform. In this case, the stimuli words were displayed on a Gateway

LCD monitor (model code 7005432) set to a resolution of 1024 X 780. Participant responses were delivered to the computer via a standard Gateway optical mouse.

Procedure

The Working Memory Experiment was completed first to induce either the control (*N* = 11) or frustrated condition, assigned randomly by seating arrangement within lab. Participants were instructed to refrain from speaking for the duration of the experiment in order to avoid disrupting other participants. This insured that none of the participants would realize that others were experiencing the same difficulties, thereby risking revealing our manipulation. Participants began each condition by pressing the spacebar on the computer's keyboard. After the brief presence of a fixation mark at the screen's center, words in the style of the current condition were presented individually in turn on the screen.

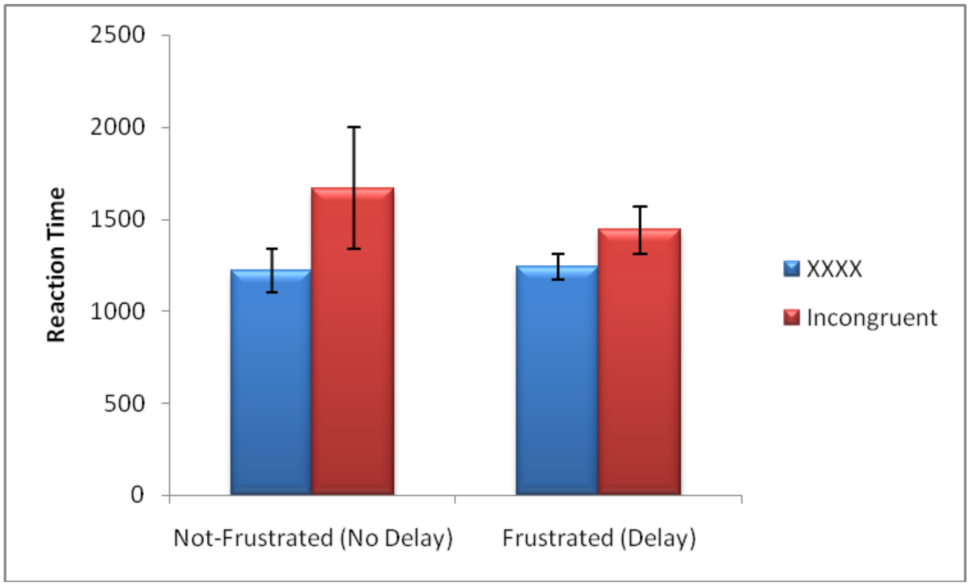
In the Working Memory experiment, each participant completed one trial consisting of four consecutive memory blocks with five words in each block. Results of the memory task, as a proportion of the words identified, were recorded to verify the impossibility of identifying each of the presented words in the frustrating condition, but were not analyzed as data.

After the induction of either the control or frustrated condition via the Working Memory experiment, the participants began either the "XXXX" or "Incongruent" Stroop condition, varied randomly in order to account for fatigue and practice effects in these conditions. There was a short break for set up between each condition. Each of the two Stroop Conditions had 25 stimuli presentations. When the word stimulus appeared on the screen, the participant was to identify the color the word was printed in as quickly as possibly by button on the screen that corresponded to that color. Therefore, if the word "green" was printed in red the participant would respond by clicking "red." How quickly the participant identified the color of the letters was recorded in the computer system and reported as a mean of the 25 trials at the end of each condition, along with the participant's accuracy in identification for that condition. Accuracy data is collected to ensure the accuracy of the participant's response times, so that if accuracy drops below a standard threshold of 90%, their reaction times are considered inaccurate and are discarded. Above that threshold, the mean reported by the program was the collected as the participant's "reaction time" for that condition. The XXXX condition established the participant's baseline reaction time for color naming, and the Incongruent condition was taken as a measure of color naming reaction time with the interference of the automatic reading process.

Results

Each of the participant's mean reaction times for each Stroop condition was compiled and sorted into frustration and non-frustration groups. From this, a mean group reaction time was computed for each of the Stroop conditions. These mean group reaction times were compared using a 2 (frustration or not) by 2 (Stroop: XXXX or incongruent) mixed factorial design with repeated measures on the second variable and at an alpha level .10. This level is justified in light of the preliminary nature of this study. Results of the ANOVA show that there is a significant interaction between frustration and the levels of the Stroop Effect, $F(1,22) = 3.189$, $p = .088$. In the non-frustrated group, introducing the automatic reading interference increased the reaction time from 1220.276 milliseconds to 1667.882 milliseconds, while in the frustrated group introducing the automatic reading interference increased reaction time from 1240.262 milliseconds to 1440.362 milliseconds. The significant interaction indicates that the latter increase is significantly smaller than the former. These results are displayed in Figure 1. The lines atop each bar signify the 95% confidence interval of the mean for each condition.

Figure 1. The effect of frustration on each condition of the Stroop Task.



Discussion

Our results show that frustrated participants significantly performed with greater speed in the incongruent condition of the Stroop task than non-frustrated participants. What this means is that when using attention to override the interference due to the automatic process of reading, frustrated participants outperformed non-frustrated participants. These results do not support the study's hypothesis, as it was expected that frustration would inhibit a participants' attention. Perhaps frustration constricts attention not in a manner that inhibits it, but in a manner that focuses it.

Although the frustration manipulation appeared to be effective as many participants reported destructive feelings of anger towards their computer, the frustration manipulation could not control for prior levels of frustration among participants, nor for how resilient participants were to frustration. Although random selection helps control for these individual characteristics that would otherwise be confounding variables, the results could still be skewed by participants in the control condition who happened to come into the test frustrated, or participants in the frustration condition who appeared to the researchers to be unaffected by the manipulation. The accuracy of naming the color in the Stroop task rarely dipped below 100% indicating that participants were engaged in the task. Previous research shows, however, that if these engaged participants did not invest their self-esteem into their performance they may not have been affected by the frustration manipulation (Kuppens, et al. 2007). In addition, perhaps a stronger manipulation could be created to generate frustration.

For future researchers to conduct this study, a stronger manipulation to create frustration in participants may be helpful in finding significant results. Should there be a way to account for more of the possible faults in our own manipulation, there may be greater success in creating the frustration and making it enough of a frustration to last into the tasks following the manipulated task. It would also be interesting to look into how this frustration works on other cognitive abilities such as memory or problem solving. Perhaps other forms of cognition do not experience the same impacts as the one that we studied. Future studies should work to explore the mechanisms behind the effect of frustration on participants. With the format of our own study, we are only aware of an outcome, but not how that outcome came about. We essentially ran a pre and post-test and have a result, but we are unaware if the results come from focusing participant's attention on the task or if the frustration inhibits automatic processes.

One important consideration for both the limitations and future directions of this study is that frustration may focus attention in such a way that the fovea constricts. That is, the frustrated participant is somehow less aware of what happens outside of their fovea. The Stroop Task is presented within a participant's fovea vision. No stimulus measuring performance in the Stroop task occurs outside of the fovea. The limits to attention due to frustration are not effectively assessed by the Stroop Task. Instead a task that presents stimulus within and outside of a participant's fovea may find failure. Future research could study the effects of frustration on the Dual-Task experiment which measures how well a participant attends to stimuli occurring inside and outside their attention.

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