Research Report

Suggestion Reduces the Stroop Effect

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ABSTRACT—*We examined the effects of suggestion on Stroop interference in highly suggestible individuals. Participants completed the Stroop task with and without a suggestion to perceive Stroop words as meaningless symbols. Half the participants were given this suggestion in hypnosis, and half were given the suggestion without the induction of hypnosis. Suggestion produced a significant reduction in Stroop inhibition, accounting for about 45% of the variance in Stroop responding, regardless of whether hypnosis had been induced. These findings indicate that suggestion can at least partially overcome the automaticity associated with the Stroop effect.*

Cognitive processes are typically categorized as either controlled or automatic (Shiffrin & Schneider, 1977). Some processes are thought to be innately automatic; others become automatic through practice (Spelke, Hirst, & Neisser, 1976). Once automatized, these processes are initiated unintentionally and cannot be prevented or stopped. The study described here addresses the question of whether a process that has become automatized can be de-automatized and brought under top-down control.

Reading words is considered to be automatic; a proficient reader cannot withhold accessing word meaning despite explicit instructions to attend only to the color in which the words are printed. The Stroop task provides evidence for the automaticitiy of reading: Participants are usually slower and less accurate in identifying the ink color of an incongruent color word (e.g., the word “BLUE” printed in red) than in identifying the ink color of either a neutral or a congruent word (e.g., “LOT” or “RED” printed in red; Stroop, 1935). The Stroop effect—the difference in responses to incongruent and congruent stimuli—is one of the most robust and well-studied phenomena in attentional research (MacLeod, 1991; MacLeod & MacDonald, 2000). The standard account maintains that words are processed automatically to the semantic level and that the Stroop effect is the “gold standard” of automated performance (MacLeod, 1992).

Certain meditative disciplines address de-automatization (Dillbeck, 1982), and there is some sparse evidence that these disciplines can be used to reduce Stroop interference (Alexander, Langer, Newman, Chandler, & Davies, 1989; Wenk-Sormaz, 2005). In addition, the Stroop effect can be significantly reduced or eliminated within certain contexts (Besner, 2001; Melara & Algom, 2003), which suggests that a seemingly automatic process can be derailed. In this study, we sought to determine whether a simple suggestion to experience Stroop words as meaningless symbols in a foreign language could modulate the Stroop effect in highly suggestible individuals. The procedure was based on a series of recent studies in which Raz and his colleagues used a posthypnotic suggestion (i.e., a suggestion made during hypnosis indicating that a particular experience or behavior will occur on cue following termination of the hypnotic session) to reduce the Stroop effect (Raz, 2004; Raz, Fan, & Posner, 2005; Raz et al., 2003; Raz, Shapiro, Fan, & Posner, 2002). In the study reported here, we sought to establish whether suggestion could reduce Stroop interference without hypnotic induction because studies have shown that responses obtained during hypnosis can also be produced without inducing hypnosis (Barber & Glass, 1962; Braffman & Kirsch, 1999; Hilgard & Tart, 1966; Hull, 1933; Weitzenhoffer & Sjoberg, 1961). If the Stroop effect can be modulated by simple suggestion without the induction of hypnosis, the effect reported by Raz and his colleagues would have wider implications than heretofore believed. It would indicate that a cognitive process generally thought to be automatic can be modified by suggestion and that this process is not a function of atypical or abnormal consciousness. A secondary aim was to replicate the modulation of the Stroop effect in an independent laboratory.

METHOD

Participants

Participants were 25 proficient readers of English (15 females), who agreed to participate in this study in exchange for credit in a

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psychology course at the University of Connecticut. Some of them may have been exposed to the card version of the Stroop test in class. All participants scored in the highly suggestible range (5–7) of the Connecticut adaptation of the Carleton University Responsiveness to Suggestion Scale (CURSS:C; Comey & Kirsch, 1999). Candidates were screened for normal color vision and were permitted to participate only if they had normal or corrected-to-normal vision. Half of the participants were randomly assigned to the hypnosis condition, and the others to the no-hypnosis condition.

Materials and Apparatus

Like the original CURSS (Spanos, Radtke, Hodgins, Bertrand, & Stam, 1981), the CURSS:C consists of a hypnotic induction followed by seven suggestions; scores are obtained by having participants indicate whether they made the requisite response to each suggestion. For example, one suggestion indicates that the person's arm will feel lighter and rise into the air. The participant is subsequently asked to estimate whether his or her arm rose at least 6 in. We invited highly suggestible individuals to participate in the experiment, but did so in such a way that the invitation did not appear related to the suggestibility screening. We used the same Stroop materials that were used by Raz et al. (2002). Participants sat at a viewing distance of approximately 65 cm in front of a color computer monitor. Stimuli consisted of single words, each displayed in one of four colors (red, blue, green, or yellow). They appeared at the center of the computer screen, where a black fixation cross was visible. All characters were displayed in uppercase font against a white background, and the stimuli subtended visual angles of 0.5° vertically and 1.3° to 1.9° horizontally (depending on word length). Two classes of words were used: color words (*RED*, *BLUE*, *GREEN*, and *YELLOW*) and neutral words (*LOT*, *SHIP*, *KNIFE*, and *FLOWER*), the two classes being matched in frequency as well as length.

Three experimental conditions were employed: a *congruent* condition, in which each color word was displayed in its own color; a *neutral* condition, in which each neutral word was displayed in any one of the four colors; and an *incongruent* condition, in which each color word was displayed in any of the three colors other than the one to which it referred (e.g., the color word "BLUE" displayed in green). Participants were asked to indicate the color in which each word was written by depressing one of four keys on a keyboard. The color-labeled response keys were "V," "B," "N," and "M" for the colors red, blue, green, and yellow, respectively. Two fingers of each hand were used to press these response keys (i.e., left middle finger for "V," right index finger for "N," etc.). Speed and accuracy were emphasized equally.

Design and Procedure

Each participant engaged in the Stroop task twice, once after activation of a suggestion that the stimuli would appear to be meaningless symbols and once without the activation of the suggestion, with a 15-min rest between these two sessions. Order was counterbalanced, so that half of the participants were randomly assigned to do the Stroop task first without the suggestion and half to do it first with the suggestion. In addition, half of the participants were randomly selected to receive a standard hypnotic induction (Kirsch, Lynn, & Rhue, 1993) prior to hearing the suggestion. In the no-hypnosis condition, participants were simply told to relax, close their eyes, and listen carefully; the suggestion was then given. Thus, the experimental design was a mixed model with hypnosis as a between-subjects factor and congruency (congruent, neutral, incongruent) and suggestion as within-subjects factors.

Each participant was told that suggestions might be administered at certain points during the experiment and that he or she would be asked to play a computer game (i.e., Stroop task) with the experimenter present in the room. The participant was instructed to focus his or her eyes on a fixation cross at the center of the screen. Then, a stimulus appeared on the screen, replacing the crosshair. The stimulus remained on the screen for a maximum of 2 s or until the participant responded. Following a response, veridical visual feedback was provided (i.e., "CORRECT" or "INCORRECT" was flashed in black), and the fixation cross was redisplayed at the center for a variable duration contingent upon the subject's reaction time (RT). At this point, a new stimulus appeared on the screen, again replacing the fixation cross and beginning the next trial. The interstimulus interval was 4 s.

Thirty-two practice trials preceded the first experimental session for each subject. This training session was used to confirm that participants were able to understand the task, proficiently map the four display colors to the appropriate response keys, and respond quickly and accurately. Following this brief training session, a hypnotic induction was administered to the participants who had been randomly assigned to the hypnosis condition. The others were given a rest period of equivalent length. Then the following tape-recorded suggestion was administered to all participants:

> Very soon you will be playing the computer game. When I clap my hands, meaningless symbols will appear in the middle of the screen. They will feel like characters of a foreign language that you do not know, and you will not attempt to attribute any meaning to them. This gibberish will be printed in one of four ink colors: red, blue, green, or yellow. Although you will only be able to attend to the symbols' ink color, you will look straight at the scrambled signs and crisply see all of them. Your job is to quickly and accurately depress the key that corresponds to the ink color shown. You will find that you can play this game easily and effortlessly. When I clap my hands twice, you will regain your normal reading abilities.

Hypnosis was then terminated for participants who had been hypnotized. Participants then completed 144 experimental trials, presented in random order. The trials were equally divided among the neutral, congruent, and incongruent conditions. For participants in the suggestion-first condition, these trials were preceded by the hand clap, which was the signal to activate the suggestion. At the end of this first set of trials, participants in the suggestion-first condition heard a double hand clap, which was the signal for canceling the suggestion. Following a 15-min rest period, participants completed another set of 144 experimental trials, again in random order. For participants in the in the suggestion-second condition a single hand clap preceded this second set of trials, and a double hand clap followed it.

RESULTS

Table 1 shows mean RTs and error scores as a function of hypnosis condition, suggestion condition, and Stroop congruency condition (congruent, neutral, or incongruent), as well as order of the suggestion conditions. Incorrect responses were excluded from the RT analyses, as were latencies that were 3 standard deviations either above or below the mean. About 2% of the data were excluded because of deviant RTs.

Stroop interference effects are assessed as differences in RTs between incongruent and neutral trials. Stroop facilitation effects are assessed as differences in RTs between congruent and neutral trials. Therefore, one way of reducing Stroop interference effects (or enhancing Stroop facilitation effects) would be to respond more slowly on neutral trials, while responding optimally on other trials. To assess the possibility that participants were slowing their responses on neutral trials, we examined differences in responding on these trials using a 2 × 2 (Suggestion × Hypnosis) mixed-model analysis of variance (ANOVA). This analysis did not reveal any significant differences.

Table 2 presents the results of calculations based on the data in Table 1: the overall Stroop inhibition effect (incongruent – congruent), as well as the breakdown into the effects of interference (incongruent – neutral) and facilitation (neutral – congruent). These data were analyzed with 2 × 2 × 2 (Suggestion × Hypnosis × Order) mixed-model ANOVAs. The ANOVAs on RT differences revealed main effects of suggestion on differences between congruent and incongruent trials, $F(1, 21) = 21.40, p < .001, \eta^2 = .51$, and on differences between neutral and incongruent trials, $F(1, 21) = 16.24, p < .001, \eta^2 = .44$. In both cases, Stroop effects were smaller with suggestion than without suggestion. There was also a main effect of order on differences between congruent and incongruent trials, $F(1, 21) = 6.05, p < .05, \eta^2 = .22$. These Stroop effects were smaller in participants who were given the Stroop task first without suggestion than in those who were given the task with suggestion first. The ANOVA on differences between congruent and neutral trials failed to reveal any significant differences for Stroop facilitation, and there were no significant main effects or interaction involving hypnosis for any variable. Also, there were no interactions with order involving any of the RT measures.

The ANOVAs on error rates failed to reveal any significant differences as a function of hypnosis or suggestion condition. Stroop error rates were not significantly correlated with Stroop RTs. This suggests that the effect of suggestion on Stroop RT was not due to participants responding less carefully in the suggestion condition than in the no-suggestion condition.

DISCUSSION

Consistent with the results of previous research (Raz, 2004; Raz, Fan, & Posner, 2005; Raz et al., 2002, 2003; Raz & Shapiro, 2002), our data indicate that a specific suggestion to construe words as meaningless symbols of an unknown foreign language substantially reduces the Stroop effect in highly suggestible individuals. To our knowledge, this is the first replication of this effect in an independent laboratory. Furthermore, our findings indicate that suggestive reduction of Stroop interference is accomplished regardless of whether hypnosis is induced. In other words, it is suggestion rather than hypnosis that reduces the Stroop effect. This finding shifts the focus concerning the influence of suggestion on the Stroop effect from the realm of altered consciousness into that of the cognitive neurosciences.

TABLE 1

Mean Reaction Times and Errors as a Function of Experimental Condition

	Suggestion				No suggestion			
	Hypnosis		No hypnosis		Hypnosis		No hypnosis	
Congruency	S-NS	NS-S	S-NS	NS-S	S-NS	NS-S	S-NS	NS-S
	Reaction time (ms)							
Congruent	634 (100)	569 (52)	672 (174)	527 (32)	606 (84)	594 (83)	616 (122)	531 (72)
Neutral	656 (95)	594 (60)	694 (149)	570 (46)	652 (58)	624 (98)	671 (133)	554 (59)
Incongruent	740 (149)	617 (78)	752 (173)	600 (48)	774 (112)	689 (81)	754 (184)	628 (84)
	Errors (%)							
Congruent	5.9 (6.1)	6.6 (5.5)	4.9 (3.1)	5.7 (8.0)	4.2 (4.8)	1.0 (1.7)	4.5 (4.5)	4.5 (10.1)
Neutral	10.4 (12.8)	5.6 (3.6)	2.8 (2.2)	7.1 (10.8)	6.3 (6.6)	3.8 (2.4)	2.4 (2.8)	8.9 (9.3)
Incongruent	18.8 (14.2)	4.2 (2.9)	4.9 (3.9)	7.1 (9.4)	10.1 (6.8)	3.5 (2.5)	5.6 (2.1)	7.4 (9.1)

S-NS = Suggestion condition prior to No-Suggestion condition; NS-S = No-Suggestion condition prior to Suggestion condition.
Note. Standard deviations are in parentheses. $n = 7$ for NS-S and 6 for all other orders.

TABLE 2
Mean Stroop Interference and Facilitation Effects as a Function of Experimental Condition

	Suggestion		No suggestion	
Subtraction effect	Hypnosis	No hypnosis	Hypnosis	No hypnosis
	Reaction time (ms)			
Incongruent – congruent	77 (70)	76 (50)	132 (54)	116 (52)
Incongruent – neutral	53 (66)	43 (43)	94 (75)	78 (45)
Neutral – congruent	28 (30)	33 (38)	38 (36)	38 (28)
	Errors (%)			
Incongruent – congruent	5.2 (11.4)	0.8 (3.0)	4.2 (4.0)	2.1 (4.7)
Incongruent – neutral	3.5 (8.7)	1.0 (2.6)	1.7 (3.9)	0.6 (3.9)
Neutral – congruent	1.7 (8.0)	−0.2 (3.8)	2.4 (2.8)	1.4 (4.6)

Note. Standard deviations are in parentheses.

The Stroop effect is believed to indicate that processing of irrelevant information takes place even when it is unfavorable to the task at hand. Because the Stroop effect is a vigorous attentional phenomenon and is difficult to reduce by practice, there is widespread accord in the literature that skilled readers obligatorily process as words printed stimuli presented to the fovea. Our data, in conjunction with previous assays, confirm that within specific contexts, the Stroop effect can be significantly reduced (Raz, Fan, & Posner, 2005), and in some cases completely eliminated (Raz et al., 2002, 2003). This, in turn, suggests that cognitive processes that have been automatized through practice can be de-automatized and brought under cognitive control.

Unlike in our previous research, the present data show that Stroop interference was not completely removed. A similar reduction was recently reported in a neuroimaging study (Raz, Fan, & Posner, 2005). However, the reduction, rather than removal, of the Stroop effect in the context of imaging was likely due to the specific constraints of the imaging conditions (Raz, Lieber, et al., 2005). Furthermore, there were methodological differences between the current study and previous studies. These differences include the setting, participant population, suggestibility scale used to screen participants, participants' prior familiarity with the Stroop task, prestige of the experimenter, and manner in which the suggestion was administered (audio-taped vs. live). It remains to be determined why suggestion removes the Stroop effect in some studies but only reduces the effect in others.

We conclude that a suggestion to construe words as meaningless scribbles markedly reduces the Stroop effect in highly suggestible individuals and that this effect does not depend on the induction of hypnosis. In conjunction with previous studies of this effect, the current study challenges the dominant view that word recognition is obligatory for proficient readers. Effective suggestion must operate through a top-down mechanism that modifies the processing of input words (Raz, 2004). Studying the brain mechanisms subserving suggestion will likely elucidate its top-down influences (Raz, Fan, & Posner, 2005) and may also shed light on such factors as anticipation and placebo (Wager et al., 2004).

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