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Can suggestion obviate reading? Supplementing primary Stroop evidence with exploratory negative priming analyses

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ABSTRACT

Using the Stroop paradigm, we have previously shown that a specific suggestion can remove or reduce involuntary conflict and alter information processing in highly suggestible individuals (HSIs). In the present study, we carefully matched less suggestible individuals (LSIs) to HSIs on a number of factors. We hypothesized that suggestion would influence HSIs more than LSIs and reduce the Stroop effect in the former group. As well, we conducted secondary post hoc analyses to examine negative priming (NP) – the apparent disruption of the response to a previously-ignored item. Our present findings indicate that suggestion reduces Stroop effects in HSIs. Secondary analyses show that LSIs had an NP effect at baseline (i.e., without suggestion) and that suggestion influenced the NP condition. Thus, at least in this experimental context, suggestion seems to dampen a deeply-engrained and largely automatic process – reading – by wielding a larger influence on HSIs relative to comparable LSIs.

1. Introduction

Most proficient readers cannot withhold accessing word meaning despite precise instructions to attend only to the ink color. The Stroop task provides evidence for the automaticity of reading (Stroop, 1935). Modern versions of this task show that when the ink color and the color word are incongruent (e.g., the word RED displayed in green ink), participants are slower and less accurate to respond "green" to the ink color compared to control items (e.g., the word LOT or the string XXX printed in green). Extensively studied in attention research, Stroop tasks and Stroop-like paradigms abound (MacLeod, 1991; MacLeod & MacDonald, 2000) and comprise the "gold standard" of automated performance (MacLeod, 1992). However, several studies – including a few using the influence of suggestion (Raz, Fan, & Posner, 2005; Raz, Shapiro, Fan, & Posner, 2002) – have challenged the automaticity claim by proposing that the assumed automatic processes underlying reading may be more malleable than heretofore acknowledged.

Using standard psychological tools (Shor & Orne, 1962; Weitzenhoffer & Hilgard, 1962), researchers can characterize individuals as either highly suggestible individuals (HSIs) or less suggestible individuals (LSIs). Following anecdotal reports from select individuals (MacLeod & Sheehan, 2003; Schatzman, 1980) and personal communications (e.g., Thalia Wheatley, Harvard University, 2002; Stanley Fisher, Albert Einstein College of Medicine, 2000), multiple Stroop studies have examined cognitive processing differences between highly suggestible individuals (HSIs) and less suggestible individuals (LSIs) as a function of a post-hypnotic suggestion (Raz, Kirsch, Pollard, & Nitkin-Kaner, 2006; Raz, Moreno-Iniguez, Martin, & Zhu, 2007; Raz et al., 2002, 2003, 2005). The crux of these reports proposed that a specific post-hypnotic suggestion degraded

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the Stroop effect in HSIs. A few researchers were able to replicate these findings at the individual – but not group – level (e.g., personal communication from Amanda Barnier, University of New South Wales, Australia, 2005); however, other researchers have been able to replicate the wholesale effect based on the suggestibility of participants even without ritualistic inductions such as those common in hypnosis (Raz et al., 2006). Although other researchers have challenged the automaticity of the Stroop effect without resorting to suggestion (Besner, 2001; Besner & Stolz, 1999a, 1999b, 1999c; Besner, Stolz, & Boutilier, 1997; Dishon-Berkovits & Algom, 2000; Kuhl & Kazén, 1999; Long & Prat, 2002; Melara & Algom, 2003; Pansky & Algom, 2002), most scholars continue to regard Stroop tasks as the apotheosis of automatic performance (Brown, Gore, & Carr, 2002; Brown, Joneleit, Robinson, & Brown, 2002).

In the present study, we wanted to conduct a typical Stroop task – drawing on a large and carefully matched sample – that would examine the differences in the influence of suggestion between HSIs and LSIs. As our primary hypothesis and in line with our previous reports, we expected that HSIs, compared to LSIs, would manifest a compelling reduction of the Stroop effect as a function of suggestion. In addition, as a surrogate exploration across the relatively large sample size, we extracted and analyzed post hoc the negative priming (NP) conditions for each participant. NP is a robust measure consisting of a pair of trials wherein the word ignored in Stimulus1 is identical to the ink color of the immediately following Stimulus2. In such cases, response time (RT) to Stimulus2 is typically longer than if Stimulus1 contained a word that did not become the ink color in Stimulus2 (Neill, 1977; see Mayr & Buchner, 2007 for a review). Our secondary hypothesis, therefore, was that, with suggestion, HSIs would show reduced NP compared to LSIs. NP is an advantageous supplementary index to Stroop performance because it is relatively immune to ulterior strategies that participants may adopt and because influencing a stepwise procedure is extremely difficult to manage consciously (Tipper, 2001). Thus, if suggestion reduced the Stroop effect in a large cohort, we would expect it to reduce NP as well.

2. Method

2.1. Participants

To measure the quantifiable rating of participants' response to suggestions under standard conditions, we screened volunteers for hypnotic suggestibility using both the Harvard Group Scale of Hypnotic Susceptibility Form A (HGSHS-A) (Shor & Orne, 1962) and the Stanford Hypnotic Susceptibility Scale, Form C (SHSS-C) without the ammonia challenge for anosmia (Weitzenhoffer & Hilgard, 1962). Participants were 83 proficient readers of English (38 female) aged 20–41 (mean = 29) years, all of whom had normal or corrected-to-normal vision. Having screened about 500 individuals on these two scales, we identified 49 participants scoring in the highly suggestible range (10–11 of a possible 11 on the SHSS-C; top 5% of HGSHS-A). We matched the remaining 34 participants – scoring in the less-suggestible range (0–1 of a possible 11 on the SHSS-C; bottom 5% of HGSHS-A) – to the HSIs using age, sex, handedness, education, and gross socio-economic status (SES) and cultural determinants. Most participants were medical and graduate students.

2.2. Materials

Each stimulus consisted of a single word written in one of four ink colors (i.e., red, blue, green, or yellow), which appeared in the center of the monitor where a black fixation cross was visible. All characters were in upper-case font against a white background, and the stimuli subtended visual angles of 0.5° vertically and 1.3–1.9° horizontally depending on the word length.

We used two classes of words in our classic Stroop paradigm: color words (RED, BLUE, GREEN, and YELLOW) and neutral words (LOT, SHIP, KNIFE, and FLOWER) and matched both classes for length as well as lexical frequency. Using Excel code, we extracted NP conditions by comparing every incongruent trial to the preceding trial (i.e., Stimulus1) for each participant. If Stimulus1 was incongruent, and the word of Stimulus1 matched the ink color of Stimulus2, the pair comprised an NP condition. Control conditions (CTRLs) for the NP condition consisted of an incongruent trial pair wherein the word ignored in the first trial was different from the ink color of the immediately following trial. As such, both trials of a pair had to be incongruent for the trial to potentially constitute an NP or CTRL condition. This operationalization of NP is common in cognitive psychology (Neill, 1977). Fig. 1 depicts NP and CTRL pairs within our Stroop task.

For the Stroop task, three experimental conditions were applied: a congruent condition, in which each color word was presented in its own color; a neutral condition, in which each neutral word was presented in any of the four colors; and an incongruent condition, in which each color word was presented in any of the three colors other than the one to which it referred (e.g., the color word RED presented in green). During each trial, participants were asked to indicate the ink color in which a word was presented in by pressing one of four keys on a keyboard. The color-labeled response keys were "V", "B", "N" and "M" for colors red, blue, green, and yellow, respectively. Two fingers of each hand were used to press the response keys (i.e., left middle finger for "V", right index finger for "N", etc.). Speed and accuracy were emphasized equally.

2.3. Design and procedure

Participants sat at a viewing distance of approximately 67 cm in front of a color computer monitor. They were instructed to focus their eyes on a fixation cross in the center of the monitor. A stimulus would follow, replacing the crosshair. The stim-

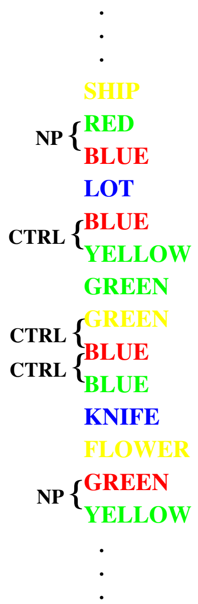

Fig. 1. Examples of negative priming (NP) and control (CTRL) trials embedded in the Stroop task.

ulus 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 ink), and the fixation cross was redisplayed at the center for a variable duration contingent upon the participant's 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.

All participants were told that suggestions might be administered at certain points during the experiment. When the suggestion condition occurred, one of the authors (AR) administered a standard Stanford induction with the following post-hypnotic suggestion:

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 be able to attend to the symbols' ink color only, 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.

Participants were then brought back to their common wakefulness. This procedure was administered to both HSIs and LSIs just prior to the computer testing. Thus, by the time participants were ready to perform on the task, they were dehypnotized with only a lingering post-hypnotic suggestion to be triggered by a cue (i.e., the hand clap). In compliance with stipulations imposed by the ethics committee, at the end of the experiment we ascertained that the post-hypnotic suggestion was void. Under the suggestion absent condition, participants were conventionally instructed to respond as quickly and as accurately as possible to the ink color of the visual stimuli.

Seventy-three of the 83 participants performed the Stroop task twice, once without the abovementioned post-hypnotic suggestion and once with the suggestion following a standard hypnotic induction (Weitzenhoffer & Hilgard, 1962). We provided a 15-min rest between sessions. Order was counterbalanced so that every even participant would do the Stroop task without suggestion-first and every odd participant would do it with suggestion-first. In addition, for 10 HSIs, five participants performed the Stroop task only without suggestion, and five participants performed the task only with suggestion.

Thirty-two practice trials preceded the first experimental session for each participant. This training session confirmed 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, participants took a short break and 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 suggestion-second condition, a single hand clap preceded this second set of trials, and a double hand clap followed it.

2.4. Statistical analysis

Because of a tradeoff between RT and accuracy, we present results for both alongside their respective interactions. While RT is a continuous variable with normal distribution, accuracy is a binary variable that is not normally distributed (i.e., it is heavily skewed toward 100%). Accordingly, we performed statistical procedures using PROC MIXED and PROC GENMOD for RT and accuracy, respectively, using the General Linear Model (GLM) of SAS v.9.1 (SAS Institute Inc., Cary, NC). Prior to conducting a confirmatory statistical analysis, we conducted exploratory analyses including means, variances, plotting the data in box-plots, histograms, and scatter-plots, to develop a solid descriptive understanding of our data sets. For continuous response, we used the GLM including between-subjects factors, within-subjects factors, and their interactions to calculate parameter estimates, 95% confidence intervals, and test-related hypotheses.

3. Results

3.1. Primary analyses

We discarded incorrect responses and mistrials from RT analyses. The remaining RT data were subjected to a recursive outlier analysis where measurements either above or below two standard deviations from the mean score for each participant in each condition were eliminated from further analyses (Van Selst & Jolicoeur, 1994). This process eliminated 4% of the

Table 1
Response time (RT) and Accuracy as a function of congruency condition. Brackets delineate analysis of specific effects (I–C, N–C, I–N). Standard errors appear in parentheses. See Table 2 for *F*-values.

Measure	Suggestibility	Congruent	Neutral	Incongruent	Facilitation (N-C)	Interference (I-N)	Stroop (I-C)
Mean RT (ms)							
Suggestion Absent	High	641 (3.4)	681 (3.7)	759 (5.2)	***	***	***
	Low	663 (4.7)	686 (4.6)	779 (6.5)	**	***	***
Suggestion Present	High	636 (3.3)	646 (3.5)	652 (3.9)			*
	Low	663 (4.7)	680 (4.8)	714 (5.8)	*	***	***
Mean Raw Accuracy (%)							
Suggestion Absent	High	96.2 (0.4)	95.2 (0.4)	93.0 (0.5)	*	**	***
	Low	95.6 (0.4)	94.5 (0.5)	92.6 (0.6)		**	***
Suggestion Present	High	94.1 (0.4)	94.1 (0.5)	93.8 (0.5)			
	Low	94.7 (0.5)	93.7 (0.5)	93.5 (0.5)			

* $p < 0.05$.
** $p < 0.005$.
*** $p < 0.0001$.

raw data. Administration order (Suggestion-first, Suggestion-second) was not significant and the data were accordingly collapsed.

Table 1 presents the mean RT and accuracy scores for the two suggestion conditions (i.e., Suggestion Present vs. Absent) as a function of the three Stroop conditions (i.e., Congruent, Neutral, and Incongruent). We assessed Stroop interference effects as differences in RTs between incongruent and neutral trials (I–N) and Stroop facilitation effects as differences between congruent and neutral trials (N–C). Table 1 summarizes the analysis of variance (ANOVA) analyses of Stroop, interference and facilitations effects, addressing RT and accuracy separately. While all three effects were significant for RT in the absence of suggestion, suggestion removed both interference and facilitation effects for HSIs.

We carried out a repeated-measures omnibus ANOVA to investigate RT (using PROC MIXED) and accuracy effects (with both PROC MIXED and PROC GENMOD to account for skewed distributions) using Suggestibility (HSIs, LSIs) as a between-subject factor, Suggestion (Present, Absent), and Congruency (Congruent, Neutral, Incongruent) as within-subject factors. For the RT analysis, all three main effects were significant: Congruency ($F(2, 162) = 288.09$, $p < .0001$), Suggestibility ($F(1, 81) = 115.28$, $p < .0001$), and Suggestion $F(1, 71) = 193.38$, $p < .0001$). All of the interactions also were significant: between Suggestion ∗ Congruency ($F(2, 142) = 94.02$, $p < .0001$), Suggestion ∗ Suggestibility ($F(1, 71) = 25.13$, $p < .0001$), Suggestibility ∗ Congruency ($F(2, 162) = 5.99$, $p < .005$) and Suggestion ∗ Suggestibility ∗ Congruency ($F(2, 142) = 4.22$, $p < .05$). Accuracy analysis with PROC MIXED and PROC GENMOD were comparable, albeit the latter (i.e., odds ratio) is a more sensitive measure. The GENMOD analysis revealed a significant main effect of Congruency ($\chi^2(2) = 20.17$, $p < .0001$) and a significant interaction of Suggestion ∗ Congruency ($\chi^2(2) = 13.36$, $p < .005$).

Table 2 presents the RT and error analysis for the Stroop, facilitation, and interference effects. Within and between-group differences correspond to solid brackets and dashed lines, respectively. With suggestion, HSIs displayed a marked reduction of the Stroop, facilitation, and interference effects whereas LSIs displayed a reduction in Stroop and interference (see solid

Table 2

Analyses of specific effects. *F*-values represent the Stroop, facilitation, and interference effects with RT and error data appearing in bubbles. Significant results appear in bold. Solid brackets depict within-group differences; dashed lines depict between-group differences. I = incongruent; N = neutral; C = congruent; $F = F(1, 374)$; $t = t(71)$.

Measure	HSI/LSI	Stroop Effect (I-C)	Facilitation Effect (N-C)	Interference Effect (I-N)
RT				
Suggestion Absent	High	(125) **$F = 414.91, p < .0001$**	(39) **$F = 48.59, p < .0001$**	(86) **$F = 181.17, p < .0001$**
		t = 5.59, ***	t = 2.34, *	t = 4.59, ***
	Low	(109) **$F = 301.45, p < .0001$**	(20) **$F = 11.91, p < .001$**	(89) **$F = 193.43, p < .0001$**
		t = 2.01, *	t = 3.59, **	t = 2.23, *
Suggestion Present	High	(18) **$F = 6.85, p < .01$**	(11) $F = 2.63, p = .106$	(7) $F = 1.00, p = .319$
		t = -2.29, *		t = -2.12, *
	Low	(65) **$F = 51.40, p < .0001$**	(19) **$F = 5.44, p < .05$**	(46) **$F = 23.26, p < .0001$**
Error				
Suggestion Absent	High	(3.3) **1.86(1.41-2.46), $p < .0001$**	(0.7) **1.24(1.02-1.51), $p < .05$**	(2.5) **1.50(1.21-1.87), $p < .0005$**
		t = -3.07, *		t = -2.47, *
	Low	(3.0) **1.73(1.42-2.12), $p < .0001$**	(1.2) 1.23(.98-1.55), $p = .068$	(1.8) **1.40(1.14-1.74), $p < .005$**
Suggestion Present	High	(0.4) 1.04(.86-1.27), $p = .693$	(0.0) 1.00(.79-1.27), $p = .988$	(0.4) 1.04(.80-1.34), $p = .775$
	Low	(1.8) 1.25(.89-1.77), $p = .198$	(1.3) 1.21(.97-1.50), $p = .086$	(0.5) 1.03(.79-1.36), $p = .792$

* $p < 0.05$.
** $p < 0.001$.
*** $p < 0.0001$.

lines). Contrasting HSIs with LSIs revealed that, without suggestion, HSIs had higher facilitation whereas with suggestion they had smaller Stroop and interference effects relative to LSIs (see dashed lines).

3.2. Secondary analyses

We recognized that embedded in our Stroop data lurked a total of 1021 NP and 2691 CTRL trial pairs and so we decided to analyze them to shed further light on the Stroop data. As for the primary analysis, we discarded mistrials and incorrect answers as well as correct answers that were more than two standard deviations from the mean. Because NP conditions, unlike CTRL conditions, require repeating the word of one trial as the color of the next trial, approximately three of every four incongruent trial pairs comprised a CTRL condition.

We carried out a repeated-measures omnibus analysis of variance (ANOVA) to investigate RT and accuracy effects across NP and CTRL. We therefore performed the following ANOVA: Suggestibility (HSIs, LSIs) as a between-subject factor, Suggestion (With, Without), and TrialType (NP, CTRL) as within-subject factors. We then followed up with post hoc analyses examining Differences of Least Square Means to explore the significant interactions. Finally, we repeated the whole analysis for the accuracy performance (i.e., error) data. The post hoc analyses for accuracy employed a non-parametric Wilcoxon two-group test to account for skewed distributions.

The omnibus analysis for RT revealed all main effects to be significant: Suggestion ($F(1, 71) = 72.63$, $p < .0001$), Suggestibility ($F(1, 81) = 17.46$, $p < .0001$), and TrialType ($F(1, 81) = 19.88$, $p < .0001$). There was a significant interaction for Suggestion $*$ Suggestibility ($F(1, 71) = 7.50$, $p < .01$). Accuracy analysis revealed a significant main effect for TrialType ($F(1, 81) = 10.70$, $p < .005$) only.

Table 3
Mean response time (RT) and accuracy of individual means for negative priming (NP) and control (CTRL) conditions. Standard errors appear in parentheses. Solid lines depict within-group differences; dashed lines depict between-group differences. Square brackets display the value for which we have enough statistical power to detect a difference. Obs. = observations; SUGG = suggestibility. For NP and CTRL, the number of trials varied between participants.

Measure	SUGG	NP: # of obs. / people	CTRL: # of obs. / people	NP condition	CTRL condition	NP effect (NP – CTRL)
Mean RT (ms)						
Suggestion Absent	High	227/44	649/44	803 (29)	783 (30)	20 [52]
	Low	180/34	527/34	864 (38)	789 (35)	75 [54]
Suggestion Present	High	223/44	599/44	679 (20)	658 (17)	21 [38]
	Low	163/33	432/34	789 (41)	740 (29)	49 [76]
Accuracy (%)						
Suggestion Absent	High	250/44	695/44	92.3 (2.1)	93.2 (1.1)	-0.9
	Low	201/34	561/34	91.1 (2.4)	94.8 (1.0)	-3.7
Suggestion Present	High	242/44	644/44	92.8 (1.8)	94.1 (1.1)	-1.3
	Low	180/33	452/34	89.6 (2.8)	96.0 (1.3)	-6.4

t(43) = −3.79, ***
t(32) = -2.34, *
t (33) = 4.05, ***
t(43) = −4.33, ****
t(33) = 2.53, *
t(32) = -2.87, **
t(33) = -3.09, **
z = -2.01, *

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.
**** $p < 0.0001$.

Table 3 presents the mean RT and accuracy scores for the NP and CTRL as a function of Suggestion (Present, Absent) and Suggestibility (HSIs, LSIs), as well as a summary of the post hoc analyses. Significant post hoc analyses revealed that at without suggestion (i.e., at baseline) the NP effect was smaller for HSIs compared to LSIs. A reduction in RTs occurred for HSIs on both NP and CTRL conditions as a function of suggestion, while LSIs dropped on NP trials only. LSIs showed longer baseline RTs to NP trials than to CTRL trials. In the presence of suggestion, HSIs showed shorter RTs, compared to LSIs, for both NP and CTRL conditions. Standard errors are greater than those presented in Table 1 due to fewer trials.

4. Discussion

While Stroop, interference, and facilitation effects were all present in the RT data for both HSIs and LSIs without suggestion, the introduction of suggestion instigated several noteworthy outcomes. In HSIs, suggestion removed both interference and facilitation effects (Table 1), sharply reducing the (I–C) Stroop effect (Table 2). In LSIs, suggestion reduced the Stroop and interference effects but not the facilitation effect, although all three effects remained reliable (Table 2). Analysis of the accuracy data revealed complementary findings. In HSIs, suggestion removed all three effects (Table 1). In LSIs, suggestion eliminated the Stroop and interference effects, but these overriding changes, unlike those seen in HSIs, were not significant (Table 2). Furthermore, in the presence of suggestion, accuracy measures for all three effects were comparable for both HSIs and LSIs. Dramatically, therefore, across the collective RT and accuracy data, Tables 1 and 2 show that suggestion can influence components of the Stroop effect in HSIs but only to a lesser extent in LSIs.

The present findings demonstrate that suggestion reduced, rather than completely obviated, the main Stroop effect. Although several case studies have reported complete Stroop removal in select individuals who likely were hypnotic virtuosos (MacLeod & Sheehan, 2003; Schatzman, 1980; personal communications from Thalia Wheatley, Harvard University, 2002; Stanley Fisher, Albert Einstein College of Medicine, 2000), few researchers have reported group elimination of the Stroop effect proposing that the experimental suggestion may have instigated an alexia-like condition in a cohort of HSIs (Casiglia et al., in press; Raz et al., 2002; Sun, 1994). Most research efforts investigating the influence of suggestion on Stroop performance report either reduction (Raz, 2006; Raz et al., 2003, 2005, 2006, 2007) or individual – rather than group – effects. In the present study, therefore, we have undertaken special efforts to match a large cohort of HSIs – who represent about 10–15% of the adult population – with LSIs of comparable background.

While suggestion affects HSIs and LSIs differently, in the absence of suggestion we observed a baseline difference between these groups only in RT for facilitation – the most tenuous of the three Stroop effects. Other researchers, however, have previously reported reliable baseline differences, including increased executive attention in HSIs compared to LSIs that extended to the Stroop and interference effects (cf. Blum & Graef, 1971; Dixon, Brunet, & Laurence, 1990; Dixon & Laurence, 1992). Further credence for this theme comes from a series of unpublished dissertations led by Laurence and his students at Concordia University. For example, replicating MacLeod and Dunbar's (1988) Stroop results, Laurence et al. showed that HSIs were likely responsible for the effect detected (Blatt, 1991). In addition, unpublished data from ten HSIs and ten LSIs using an event-related potential Stroop study showed that whereas HSIs elicited pre-P300 negativity – indexing an early onset automatic process – LSIs did not educe this brainwave component (Laurence, Slako, & Le Beau, 1998). These collective data, although drawing on modest sample sizes relative to the cohort used in the present study, propose that HSIs may possess enhanced perceptual automaticity. Furthermore, an experiment examining attention performance using "paper-and-pencil" tests showed that on the Wisconsin Card Sort Test (WCST), for example, HSIs scored consistently higher than LSIs (Moghrabi, 2004). At least some evidence, therefore, supports the idea that HSIs, compared to LSIs, likely maintain improved executive attention capacities at baseline. In the present study, however, the bulk of these differences surfaced only in the presence of suggestion.

Because we were interested in further exploring group factors, we decided to supplement our primary Stroop findings with a subsidiary NP analysis. NP indexes the automatic process which putatively reflects short-term behavior and in our paradigm provides a strong marker of semantic/lexical processing that is impervious to the peripheral strategies participants may attempt (cf. Raz et al., 2003).

Table 3 shows that suggestion instigated a significant drop in the raw NP condition – not to be confused with the NP effect – for both HSIs and LSIs, but more so in HSIs. Under suggestion, HSIs showed faster RT than LSIs for both the NP and CTRL conditions. At baseline (i.e., without suggestion), HSIs also differed from LSIs by demonstrating a difference in the NP effect (i.e., the difference between NP and CTRL trials). As well, a strong difference between NP and CTRL trials was present for LSIs without suggestion.

The secondary NP analysis has limited statistical power; it can detect a 38-ms change at best in the NP effect for RT, whereas the literature reports significant NP effects on the order of 20 ms (Neill, 1977). Power is the probability of detecting a difference given that a difference exists; however, significant *p*-values imply sufficient power by definition. Thus, for example, the baseline difference between NP and CTRL for LSIs is veridical. The problem, however, lies in that differences that appear not significant may or may not turn significant given sufficient power. For example, based on the present data, we cannot conclude whether the 20 ms NP effect observed for HSIs at baseline is significant.

Serendipitously, despite dramatic changes in NP and CTRL values as a function of suggestion, the NP effect for HSIs remained constant (around 20 ms) irrespective of suggestion. Clearly, this within-group difference is not significant regardless of power considerations and supports the notion that HSIs process information differently from LSIs. Researchers have posited that HSIs are likely to acquire and implement strategies to improve their performance at baseline because they often respond in a more efficient way relative to LSIs (Laurence, Beaulieu-Prévost, & Du Chéné, 2008). These baseline differences putatively involve various factors, including increased frontal lobe abilities and left hemispheric preference among HSIs (Horton, Crawford, Harrington, & Downs, 2004; Slako, 2002). The present findings demonstrate that the overall baseline Stroop effect was comparable between HSIs and LSIs; however, differences in the facilitation effect as well as the NP effect propose that even at baseline HSIs were probably processing words differently from LSIs. These variations likely stem from different activations, in HSIs compared with LSIs, of color, orthographic, semantic, and phonological networks and their respective interactions. Furthermore, in line with Laurence et al. (2008), the relatively small standard errors for the Stroop data and the consistency exhibited by HSIs propose that these individuals may resort to an ulterior strategy to maintain performance over and above the actual suggestion.

Our findings show that suggestion affects HSI-matched LSIs, not just HSIs. Although our secondary NP analyses reveal that LSIs show significant improvement on CTRL condition accuracy, this result likely speaks to the general trend that with suggestion participants get both faster and more accurate. Collectively, our Stroop and NP results show that suggestion seems to influence HSIs to a greater degree than LSIs. Baseline differences spanning facilitation and NP data seem more tenuous but plausible. In line with our previous studies, here too we show a connection between how one responds to suggestion and the ability to effectively process cognitive information.

The present study kept the two Stroop tasks pristine – at least in the sense that the experimental stimuli and setup were identical both times – and influenced only participants as a function of suggestion. This approach is common in studies involving meditators (Dillbeck, 1982; Ludwig & Kabat-Zinn, 2008; Lutz, Slagter, Dunne, & Davidson, 2008; Lynn, Das, Hallquist, & Williams, 2006; Tang et al., 2007; Wenk-Sormaz, 2005; Wu & Lo, 2008), including experiments involving the Stroop (Alexander, Langer, Newman, Chandler, & Davies, 1989; Wenk-Sormaz, 2005). Interpretation of these and other findings – from studies involving neither suggestion nor hypnosis and showing either reduction (Long & Prat, 2002) or removal (Kuhl & Kazén, 1999) of Stroop conflict – contends that rather than being inevitable, it may be possible to govern reading of Stroop words. Thus, a seemingly automatic process may be deautomatized (Raz et al., 2007), and hypnotic suggestions in tandem with other approaches may create adaptive response sets to deautomatize maladaptive responses (Lynn et al., 2006).

Our experimental suggestion likely operates through a top-down effect that modulates the processing of input words (Raz & Buhle, 2006). We have begun to unlock the neural correlates subserving the influence of suggestion (Raz et al., 2005). Future studies that aim by design to explore the effect of suggestion on the NP effect will better substantiate the incipient leads intimated by the present subsidiary analyses and pave the road to a more scientific understanding of the influence that suggestion exerts on cognition. We hope to report on such efforts before long.

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