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Reply

Subsidiary analysis of different Stroop-embedded negative priming trials ☆,☆☆

Natasha K.J. Campbell [a], Amir Raz [a,b,*]

[a] McGill University, 3775 University Street, Montreal, Quebec, Canada H3A 2B4

[b] Lady Davis Institute for Medical Research, 3755 Côte Ste.-Catherine Road, Montreal, Quebec, Canada H3T 1E2

1. Introduction

In his commentary, MacLeod (2011) presents a rich testing ground for elucidating how suggestion may operationalize attention. The effects of posthypnotic suggestions on Stroop performance raise theoretical questions regarding the nature of the underlying mechanisms. Beyond the methodological designs outlined by MacLeod, one way to address these questions is to examine data from embedded Stroop conditions. Negative priming (NP), for example, is an especially attractive methodology to use in the context of atypical attention because paired stepwise trials are inherently less susceptible to ulterior strategies, which could potentially minimize the Stroop effect (Raz & Campbell, 2011). Researchers can use NP as a complementary vehicle to elucidate findings (e.g., in a post-hoc fashion) or as a primary means of analysis within a sufficiently powered Stroop context specifically designed to explore such trials. In this paper we demonstrate that a meticulous exploration of the nuanced components comprising individual NP sub-effects sketches an experimental blueprint to guide future studies, especially when coupled with additional objective measures (e.g., eye-tracking and imaging of the living human brain).

Cognitive inhibition refers to an active process of suppressing irrelevant information, usually from working memory. Cognitive neuroscientists identify the prefrontal cortex as the primary locus of inhibition and distinguish it from susceptibility to interference, which occurs under conditions of multiple distracting stimuli, such as the Stroop task and dual-task performances (Harnishfeger, 1995). NP is an important form of cognitive inhibition and Tipper (1985) introduced the term "negative priming" to refer to the inhibitory effect of ignored stimuli. NP is a form of cognitive inhibition operationalized as the extent to which a subject may inhibit attention resources to distracting stimuli while focusing these resources on a target stimulus. Although cognitive inhibition, or at least the construct of NP, could be an important mechanism in determining hypnotic responsiveness, other forms of inhibition (e.g., cognitive inhibition at retrieval, behavioral inhibition, neurophysiological inhibition) may also contribute to hypnotic responsiveness.

Inhibitory tasks, such as NP, may aid in elucidating the relationship between cognitive inhibition and hypnotic responding (David & Brown, 2002; David, King, & Borkardt, 2001). These studies report significant correlations between cognitive inhibition (as assessed by NP in a semantic categorization task) and different measures of hypnotic suggestibility. Hypnotizability, for example, positively correlates with reaction time for ignored stimuli, indicating that suggestibility relates to an ability to inhibit task-irrelevant stimuli. Thus, cognitive inhibition may play a role in hypnotic responding (David & Brown, 2002). Westberry (1983) showed that, in contrast with lows, individuals scoring high on the Tellegen Absorption Scale (Tellegen & Atkinson, 1974) elicited substantial NP. Because absorption correlates with hypnotizability (cf. Kirsch, 1990; Tellegen & Atkinson, 1974) NP may also correlate with hypnotic responsiveness. A relation between the size effect of NP

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☆ We dedicate this collection of responses to the memory of Bill Banks, founding coeditor of Consciousness and Cognition. This project was the last professional interaction we had with him before his untimely parting.

☆☆ Reply to MacLeod, C. (2011). Hypnosis and the control of attention: Where to from here? *Consciousness and Cognition*, 20 (2), 321–324.

* Corresponding author. Address: 4333 Côte Ste.-Catherine, Montreal, Quebec, Canada H3T 1E4. Fax: +1 514 340 8124.
E-mail address: amir.raz@mcgill.ca (A. Raz).

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and hypnotizability would likely depend on the ability to inhibit awareness of the immediate environment or the mapping between irrelevant/disruptive stimuli and activation.

Here we carried out an analysis embedded in a Stroop data set in search of NP variations. Within a Stroop context, 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. Our analyses included the division of NP into three types: Incongruent NP (NPi), Neutral NP (NPn) and Congruent NP (NPc). Whereas most researchers typically present the NPi condition and its control (CTRLi) (Goldstein et al., 2011; Raz & Campbell, 2011), here we present the results for the NPn and NPc conditions.

2. Methods

We employed identical methods as previously reported by Raz and Campbell (2011). We extracted three types of NP conditions (NPi, NPn, and NPc) by comparing every trial to the preceding trial (i.e., Stimulus1) for each participant (see Fig. 1 for examples). We describe the NPi analysis previously (Raz & Campbell, 2011).

2.1. Neutral Negative Priming (NPn)

If Stimulus1 is incongruent and Stimulus 2 is a neutral word, and the word of Stimulus1 matches the ink color of Stimulus2, the pair comprises an NPn condition. Control trials (CTRLn) for this NPn condition subsist of a trial pair whereby the word ignored in the first incongruent trial is different from the ink color of the immediately-following neutral word trial. Embedded in our Stroop data, we identified a total of 875 NPn and 3102 CTRLn trial pairs.

2.2. Congruent Negative Priming (NPc)

If Stimulus1 is incongruent and Stimulus2 is congruent, and the word of Stimulus1 matches the ink color of Stimulus2, the pair comprises an NPc condition. Control trials (CTRLc) for this NPc condition subsist of a trial pair whereby the word ignored in the first incongruent trial is different from the ink color of the immediately-following congruent trial. Embedded in our Stroop data, we identified a total of 814 NPc and 2748 CTRLc trial pairs. Fig. 2 depicts all types of NP and CTRL pairs within a Stroop task.

3. Results

Table 1 presents the mean raw reaction time (RT) and accuracy scores for NPn, NPc, CTRLn and CTRLc as a function of Suggestion (With, Without) and Suggestibility (Highly Suggestible Individuals = HSIs, Less Suggestible Individuals = LSIs). Administration order was not significant and the data were accordingly collapsed. Incorrect responses were excluded from the RT analyses.

We carried out a repeated-measures omnibus analysis of variance (ANOVA) to investigate RT and accuracy effects across NPs and CTRLs. Therefore, we performed the following ANOVA: Suggestibility (HSIs, LSIs) as a between-subject factor,

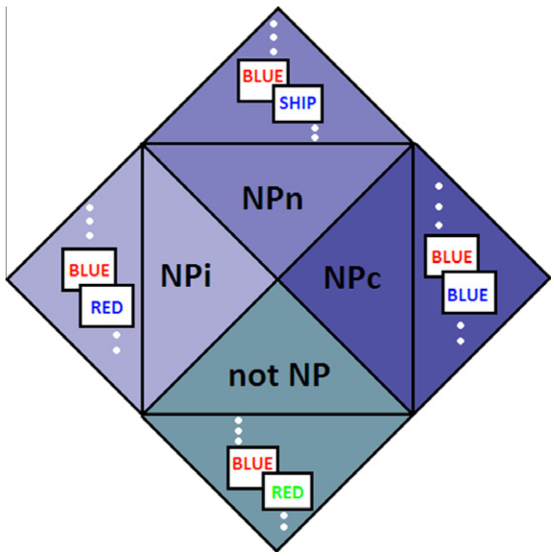

Fig. 1. Examples of Incongruent Negative Priming (NPi), Neutral Negative Priming (NPn), Congruent Negative Priming (NPc) and Non-Negative Priming trials.

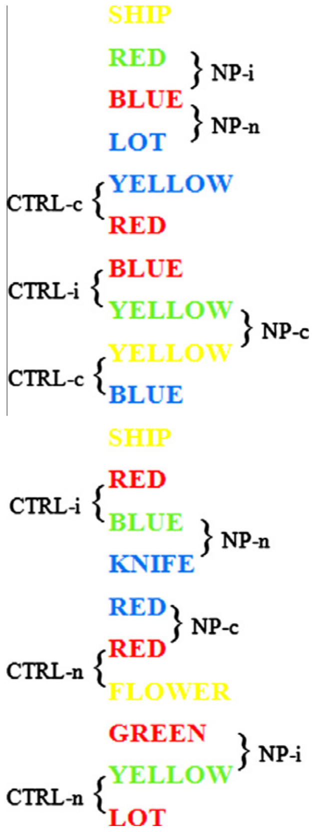

Fig. 2. Examples of Incongruent Negative Priming (NPi), Incongruent Control (CTRLi), Neutral Negative Priming (NPn), Neutral Control (CTRLn), Congruent Negative Priming (NPc) and Congruent Control (CTRLc) tasks embedded in the Stroop task.

Table 1
Mean Reaction Time (RT) and Accuracy for Neutral Negative Priming (NPn) and Control (CTRLn), as well as Congruent Negative Priming (NPc) and Control (CTRLc) conditions with standard error in parentheses.

Measure	HSI/LSI	N NPn	NPn	N CTRLn	CTRLn	N NPc	NPc	N CTRLc	CTRLc
Mean RT (ms)									
NS	High	44	720 (24)	44	686 (18)	43	710 (22)	44	656 (20)
	Low	30	751 (36)	34	704 (26)	33	742 (39)	34	686 (27)
S	High	43	702 (31)	44	648 (15)	43	685 (21)	44	631 (14)
	Low	32	714 (32)	34	684 (21)	34	701 (29)	34	675 (25)
Accuracy (%)									
NS	High	44	94.2 (1.7)	44	96.8 (0.6)	43	93.4 (1.5)	44	96.5 (0.8)
	Low	32	97.3 (2.0)	34	94.0 (1.2)	33	97.8 (1.1)	34	97.2 (0.8)
S	High	43	96.0 (1.4)	44	94.4 (1.1)	44	92.4 (2.3)	44	94.6 (1.1)
	Low	34	95.9 (1.5)	34	94.9 (1.1)	34	95.8 (1.6)	34	94.9 (1.1)

N = Number of subjects; HSI = Highly Suggestible Individuals; LSI = Less Suggestible Individuals; NS = Without Suggestion; S = With Suggestion.
Raz and Campbell (2011) presents the data for NPi and CTRLi trial pairs.

Suggestion (With, Without), and TrialType (NPi, CTRLi, NPn, CTRLn, NPc, CTRLc) as within-subject factors and 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 omnibus analysis for RT revealed main effects for Suggestion ($F(1,71) = 61.68$, $p < .0001$), Suggestibility ($F(1,81) = 18.54$, $p < .0001$), and TrialType ($F(5,404) = 49.58$, $p < .0001$). Significant interactions included Suggestion $*$ Suggestibility ($F(1,71) = 7.36$, $p < .01$), Suggestion $*$ TrialType ($F(5,345) = 10.61$, $p < .0001$), and Suggestibility $*$ TrialType ($F(5,404) = 2.97$, $p < .05$). No other interactions were significant. Accuracy analysis revealed a significant main effect for TrialType ($F(5,404) = 5.34$, $p < .0001$) only.

Table 2
Analysis for RT and Accuracy: Neutral Negative Priming (NPn) versus Control (CTRLn) conditions and Congruent Negative Priming (NPc) versus Control (CTRLc) conditions. Statistically significant results appear in bold.

Measure	HSI/LSI	NPn versus CTRLn	NPc versus CTRLc
Mean RT (ms)			
NS	High	$\mathbf{t(43) = 2.19, p < 0.05}$	$\mathbf{t(42) = 4.43, p < 0.0001}$
	Low	$\mathbf{t(29) = 2.11, p < 0.05}$	$\mathbf{t(32) = 2.68, p < 0.05}$
S	High	$\mathbf{t(42) = 2.61, p < 0.05}$	$\mathbf{t(42) = 3.65, p < 0.001}$
	Low	$t(31) = 1.78, p = 0.086$	$t(33) = 1.21, p = 0.236$
Accuracy (%)			
NS	High	$z = -0.62, p = 0.532$	$z = -0.69, p = 0.488$
	Low	$\mathbf{z = 3.15, p < 0.01}$	$z = 1.53, p = 0.125$
S	High	$z = 1.19, p = 0.231$	$z = -0.03, p = 0.974$
	Low	$z = -1.26, p = 0.201$	$z = -1.63, p = 0.103$

HSI = Highly Suggestible Individuals; LSI = Less Suggestible Individuals; NS = Without Suggestion; S = With Suggestion.

3.1. Analyses

As previously reported, LSIs without suggestion are significantly slower on NPi trials compared to CTRLi trials, while accuracy remains comparable (Raz & Campbell, 2011). Table 2 demonstrates a significantly higher RT for NPn compared to CTRLn trials, as well as NPc compared to CTRLc trials for all groups except LSIs under suggestion. Table 1 reveals that although HSIs do become faster with the induction of suggestion (e.g., NPc: 710 ms to 685 ms; CTRLc: 656 ms to 631 ms) differences between NPc and CTRLc, as well as between NPn and CTRLn, remain significant. Table 2 displays these results.

4. Discussion

As previously reported (see Table 3 (Raz & Campbell, 2011)), significant RT differences appear between HSIs and LSIs under suggestion on the NPi task. In other words, HSIs were faster than LSIs under suggestion. We found no difference, however, between the two groups for NPn, NPc, or accuracy. Furthermore, when comparing suggestion to no suggestion, we detected a significant RT difference for HSIs and LSIs on NPi trials (see Table 3 (Raz & Campbell, 2011)), but not for NPn or NPc trials (data not shown). Accuracy results are comparable. Thus, although participants experiencing NPn and NPc trials display a delayed reaction time compared to their CTRL counterparts, they do not appear to be as affected by suggestion as the ‘‘classical'' incongruent negative priming condition. By exploring these additional dimensions of this task, therefore, we find that NP, compared to other attentional tasks (e.g., the Stroop task), appears less affected by posthypnotic suggestion.

The relation between hypnotizability and the ability to inhibit information is less clear than heretofore presumed. With a sample of 180 participants, Dienes et al. (2009) found that the correlations between hypnotizability and NP or between hypnotizability and latent inhibition were close to zero, with upper limits of about 0.20. In addition, Varga, Németh, and Szekely (2011) with 116 subjects found no significant correlations between hypnotizability and reaction time measures of sustained, selective, divided or executive attention. Perhaps such results are in keeping with the view that hypnotizability largely relates to individual variations in metacognitive processes. Future studies, therefore, may wish to explore this issue further using this robust analytical approach in concert with converging methodologies.

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References

David, D., & Brown, R. J. (2002). Suggestibility and negative priming: Two replication studies. *International Journal of Clinical and Experimental Hypnosis, 50*(3), 215–228.
David, D., King, B. J., & Borkardt, J. J. (2001). Is a capacity for negative priming correlated with hypnotizability? A preliminary study. *International Journal of Clinical and Experimental Hypnosis, 49*(1), 30–37.
Dienes, Z., Brown, E., Hutton, S., Kirsch, I., Mazzoni, G., & Wright, D. B. (2009). Hypnotic suggestibility, cognitive inhibition, and dissociation. *Consciousness and Cognition, 18*(4), 837–847.
Goldstein, L. H., Newsom-Davis, I. C., Bryant, V., Brammer, M., Leigh, P. N., & Simmons, A. (2011). Altered patterns of cortical activation in ALS patients during attention and cognitive response inhibition tasks. *Journal of Neurology, 258*(12), 2186–2198.
Harnishfeger, K. K. (1995). The development of cognitive inhibition: Theories, definitions and research evidence. In F. N. Dempster & C. J. Brainerd (Eds.), *Interference and inhibition in cognition* (pp. 176–204). San Diego, CA: Academic Press.

Kirsch, I. (1990). *Changing expectations: A key to effective psychotherapy Pacific Grove*. CA: Brooks/Cole.
MacLeod, C. (2011). Hypnosis and the control of attention: Where to from here? *Consciousness and Cognition, 20*(2), 321–324.
Raz, A., & Campbell, N. K. J. (2011). Can suggestion obviate reading? Supplementing primary Stroop evidence with exploratory negative priming analyses. *Consciousness and Cognition, 20*(2), 312–320.
Tellegen, A., & Atkinson, G. (1974). Openness to absorbing and self-altering experiences ("absorption"), a trait related to hypnotic susceptibility. *Journal of Abnormal Psychology, 83*(3), 268–277.
Tipper, S. P. (1985). The negative priming effect: Inhibitory priming by ignored objects. *The Quarterly Journal of Experimental Psychology Section A, 37*(4), 571–590.
Varga, K., Németh, Z., & Szekely, A. (2011). Lack of correlation between hypnotic susceptibility and various components of attention. *Consciousness and Cognition, 20*(4), 1872–1881.
Westberry, R. L. (1983). *The nature of attentional control as a personality dimension (Doctoral dissertation)*. Unpublished doctoral dissertation. Tampa: University of South Florida.