2011, Consciousness and Cognition, 20, 727-736.

Dissociated control as a signature of typological variability in high hypnotic suggestibility

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Abstract

This study tested the prediction that dissociative tendencies modulate the impact of a hypnotic induction on cognitive control in different subtypes of highly suggestible individuals. Low suggestible (LS), low dissociative highly suggestible (LDHS), and high dissociative highly suggestible (HDHS) participants completed the Stroop color-naming task in control and hypnosis conditions. The magnitude of conflict adaptation (faster response times on incongruent trials preceded by an incongruent than those preceded by a congruent trial) was used as a measure of cognitive control. LS and LDHS participants displayed marginally superior up-regulation of cognitive control following a hypnotic induction, whereas HDHS participants' performance declined. These findings indicate that dissociative tendencies modulate the influence of a hypnotic induction on cognitive control in high hypnotic suggestibility and suggest that HS individuals are comprised of distinct subtypes with dissimilar cognitive profiles.

Keywords: cognitive control; conflict monitoring; dissociation; heterogeneity; hypnosis; hypnotic suggestibility; typology

Introduction

Responses to hypnotic suggestions are frequently accompanied by marked distortions in highly suggestible (HS) individuals' perceived control over their actions and the availability of information to consciousness (Kihlstrom, 2008). This experience of involuntariness is widely regarded as the core phenomenological property of hypnotic responding (Kirsch & Lynn, 1998; Weitzenhoffer, 1980). An influential theory of hypnosis - *dissociated control theory* - argues that responses to hypnotic suggestions are facilitated by a breakdown in executive control over response selection in HS individuals following a hypnotic induction (Woody & Bowers, 1994; Woody & Farvolden, 1998). On the basis of neuroimaging evidence (Egner, Jamieson, & Gruzelier, 2005), a revised version of this theory specifically proposes that hypnosis triggers a decoupling of executive monitoring and control functions (Egner & Raz, 2007; Jamieson & Woody, 2007; Woody & Sadler, 2008). On this account, executive control can still bias contention scheduling, but no longer consistently receives feedback from the executive monitor and thus exhibits difficulty selectively adjusting attention to meet task demands. In contrast, *social cognitive* theories of hypnosis assert that a hypnotic induction does not have a deleterious impact on executive functions in HS individuals (Lynn, Kirsch, & Hallquist, 2008).

Experimental investigations of *baseline* executive attention in low suggestible (LS) and HS individuals have produced conflicting results (for a review see Dienes, Brown, Hutton, Kirsch, Mazzoni, & Wright, 2009). Studies using selective attention tasks have alternately reported superior attention (David, King, & Borkardt, 2001; Rubichi, Ricci, Padovani, & Scaglietti, 2005), or poorer attention (Palmer & Field, 1971), among HS individuals, or no group differences across individuals of different levels of hypnotic suggestibility (Baribeau, LeBeau, Roth, & Laurence, 1994; Dienes et al., 2009; Iani, Ricci, Gherri, & Rubichi, 2006). Studies using other measures of executive functioning (e.g., Wisconsin Card Sorting Task, random number generation) have found parallel inconsistencies (Aikins & Ray, 2001; Crawford, Brown, & Moon, 1993; Graham & Evans, 1977).

Multiple experiments have found poorer selective attention, as measured by the Stroop color-naming task (Stroop, 1935), among HS individuals *following* a hypnotic induction (Gruzelier, Gray, Kaiser, & Barker, 1997; Jamieson & Sheehan, 2004; Kaiser, Barker, Haenschel, Baldeweg, & Gruzelier, 1997; Sheehan, Donovan, & Macleod, 1988). Similar effects have been reported for letter fluency (Gruzelier & Warren, 1993; Kallio, Revonsuo, Hamalainen, Markela, & Gruzelier, 2001). These results are clearly in line with the predictions of dissociated control theory (Jamieson & Woody, 2007; Woody & Bowers, 1994). However, these effects have not been observed in all studies (e.g., Egner et al., 2005) and HS individuals have been found to exhibit prominent heterogeneity in at least one study (Nordby, Hugdahl, Jasiukaitis, & Spiegel, 1999). Nordby et al. (1999) found that HS participants' error rates on the Stroop color-naming task during hypnosis varied from approximately 2% to 24%, whereas their error rates in the control condition, and LS participants' error rates across conditions, varied only from 1% to 5%.

Variability in attentional functioning among HS individuals between and within experiments is strikingly consistent with other studies demonstrating heterogeneity in this population. HS individuals exhibit diversity in multiple hypnotic dimensions including spontaneous phenomenological response to a hypnotic induction (Pekala & Kumar, 2007; Terhune & Cardeña, in press), behavioral and experiential hypnotic suggestibility (McConkey & Barnier, 2004), and the cognitive and neurophysiological mechanisms underlying hypnotic responding (Galea, Woody, Szechtman, & Pierrynowski, 2010; King & Council, 1998; Kunzendorf & Boisvert, 1996; Sadler & Woody, 2006; Winkel, Younger, Tomcik, Borckardt, & Nash, 2006).

One interpretation of heterogeneity in this population is that HS individuals are comprised of distinct subtypes with dissimilar cognitive and phenomenological profiles (Barber, 1999; Brown & Oakley, 2004; Carlson & Putnam, 1989; Kunzendorf & Boisvert, 1996). These models vary in the demarcation criteria used to discriminate different HS subtypes but agree that there is a subtype that exhibits weakened executive functioning following a hypnotic induction (henceforth high dissociative highly suggestible [HDHS] individuals), in a similar fashion to that predicted by second-order dissociated control theory (Jamieson & Woody, 2007), whereas the remainder (low dissociative highly suggestible [LDHS] individuals) maintain flexible executive control in accordance with social cognitive theories of hypnosis (Lynn et al., 2008). A corollary of dissociative typological models is that HDHS individuals will display deficits on selective attention tasks following a hypnotic induction, whereas LDHS individuals will not. Brown and Oakley (2004) further address heterogeneity in baseline attention among HS individuals by arguing that insofar as the state of consciousness achieved by the HDHS subtype during hypnosis is facilitated in part by attentional focusing, this subtype may exhibit superior baseline attention than the LDHS subtype. Similarly, proponents of dissociated control theory have noted that not all HS participants may experience hypnotic suggestions through weakened cognitive control and have speculated that there may be discrete HS subtypes (Woody & Sadler, 1998, 2008).

A number of studies have yielded evidence in support of bifurcated dissociative typological models. King and Council (1998) found that LDHS individuals exhibited lower responsiveness to a posthypnotic suggestion for alexia under cognitive load than a control condition, as would be predicted by social cognitive theories (Lynn et al., 2008), whereas HDHS individuals' responsiveness was unaffected by the cognitive load, as would be predicted by dissociated control theory (Woody & Bowers, 1994). In two studies with different methodologies, we also found evidence for a dissociative HS subtype that experiences greater spontaneous alterations in agency and more pronounced involuntariness during hypnotic responding, and a second HS subtype that displays superior object visual imagery (Terhune & Cardeña, in press; Terhune, Cardeña, & Lindgren, in press).

The present study aimed to resolve previous inconsistencies regarding the modulatory influence of hypnotic suggestibility on attention by reconsidering this relationship within the context of the dissociative typological models. We tested the prediction that disruptions in cognitive control following a hypnotic induction would be restricted to HDHS individuals. Cognitive control can be understood as the ability to selectively adjust attention in accordance with environmental demands. This form of control is necessary for optimal performance in selective attention tasks such as the Stroop task, in which individuals have to identify the color of congruently- and incongruently-colored words. Greater selective attention is required on incongruent trials in which participants have to identify a stimulus color (e.g., red) that is different from the stimulus word (e.g.,"GREEN") than on congruent trials when the two stimulus dimensions match. This task has been repeatedly noted to provide a suitable means for testing the predictions of dissociated control theory (Egner & Raz, 2007; Kirsch & Lynn, 1998), although Kirsch and Lynn (1998) have argued that impaired performance among HS individuals on this task during hypnosis may reflect increased relaxation rather than a weakening of executive control. In the present study, LS and HS participants completed the Stroop task in control and hypnosis conditions and provided self-reports of relaxation and strategy utilization (Jamieson & Sheehan, 2004; Sheehan et al., 1988). Our analyses focused on the sequential congruency effect (Egner, 2007) and response automatization (Laurence, Beaulieu-Prévost, & du Chéné, 2008; Segalowitz & Frenkiel-Fishman, 2005).

The sequential congruency effect refers to a reduction in Stroop interference following incongruent relative to congruent trials (Egner, 2007; Gratton, Coles, & Donchin, 1992). Incongruent trials that are preceded by an incongruent trial (II) are associated with faster and more accurate responses than those preceded by a congruent trial (CI). This effect remains even when feature integration effects (Hommel, Proctor, & Vu, 2004) are eliminated through the exclusion of repetition trials (Notebaert, Gevers, Verbruggen, & Liefooghe, 2006). The sequential congruency effect has been argued to reflect the up-regulation of cognitive control in the wake of response conflict (Botvinick, Braver, Barch, Carter, & Cohen, 2001). Specifically, increased response conflict between competing behavioral representations on incongruent trials is hypothesized to be gauged by conflict monitoring, which in turn communicates the requisite need for context-dependent adjustments in attention. Up-regulation of cognitive control is subsequently implemented by increasing selective attention to relevant stimulus dimensions (stimulus color) and reducing processing of irrelevant stimulus dimensions (stimulus name) (Botvinick et al., 2001; Egner, 2007). These *micro adjustments* in cognitive control (Botvinick, 2007) are the hypothesized mediator of faster response times on II relative to CI trials. We expected that HDHS participants would exhibit weaker conflict adaptation effects following a hypnotic induction, whereas LDHS and LS participants would exhibit no changes or stronger effects.

Response automatization refers to the extent to which behavioral responses become automatic. Previous research suggests that HS participants may have a heightened capacity for automaticity. Moghrabi (2004) reported a positive relationship between hypnotic suggestibility and the Stroop facilitation effect. HS individuals have also been found to exhibit faster response times in a simple reaction time task

(Braffman & Kirsch, 2001) and when identifying a stimulus in a backward masking task (Ingram, Saccuzzo, Mcneill, & Mcdonald, 1979). Dixon and Laurence (1992) similarly reported that HS individuals displayed greater baseline behavioural automaticity than LS individuals in response to color-word primes in a color-naming task. Finally, Laurence et al. (2008) observed that HS individuals displayed lower inter-trial response time variability, as measured by the coefficient of variability (CV) in a cognitive inhibition task than LS individuals, which they interpreted as reflecting an enhanced propensity for automatizing behavioral responses (Segalowitz & Frenkiel-Fishman, 2005). A notable feature of these studies is that none examined the impact of a hypnotic induction on response automatization. To further examine this relationship, we tested the prediction that HDHS participants would exhibit reduced CVs following a hypnotic induction (reflecting increased response automatization), whereas LS and LDHS participants' CVs would not differ across conditions.

Method

Participants

Three groups of individuals took part in this study: LS (n = 19), LDHS (n = 18), and HDHS (n = 11) participants. Hypnotic suggestibility was measured in group sessions with the *Waterloo-Stanford Group Scale of Hypnotic Susceptibility, Form C* (WSGC; Bowers, 1993) and in individual sessions with the *Revised Stanford Profile Scales of Hypnotic Susceptibility* (RSPS I & II; Weitzenhoffer & Hilgard, 1967), where LS: WSGC: $\leq$ 4; RSPS $\leq$ 8 and HS: WSGC $\geq$ 8; RSPS $\geq$ 20. HS subtypes were stratified according to the Swedish version (Körlin, Edman, & Nybäck, 2007) of the *Dissociative Experiences Scale* (Bernstein & Putnam, 1986; Carlson & Putnam, 1993) using a cut-off criterion of 20, corresponding to the 75th percentile for the sample (Terhune et al., in press). The three groups were matched for age (LS: M = 22.89, SD = 2.40; HDHS: M = 23.82, SD = 3.60; LDHS: M = 23.39, SD = 2.91), $F < 1$, and sex distributions (LS: 12 [67%] female; HDHS: 9 [82%] female; LDHS: 14 [74%] female]), $\chi^2 < 1$. The two HS subtypes exhibited equivalent hypnotic suggestibility on the WSGC and three out of five subscales of the RSPSs, whereas LS participants scored lower on all measures (Terhune et al., in press). All participants were right-handed (Oldfield, 1971) and had normal or corrected-to-normal vision. Participants provided informed consent and the study was approved by a local ethics committee.

Material

The Stroop task was administered on a PC computer using E-Prime v. 1.2 (Psychological Software Tools, Pittsburgh, PA). Participants were seated at a distance of 75 cm from the computer monitor. Stimuli, subtending a visual angle of 5.3° × 1.5°, consisted of one of three color words (RÖD [RED], GRÖN [GREEN], BLÅ [BLUE]) printed in one of the three corresponding ink colors and were presented in quasi-random fashion with 67% of trials being incongruent. Stimuli were centered on the vertical and horizontal axes of a 33 cm monitor and were presented for 1200 ms. Interstimulus intervals consisted of a centrally-presented white fixation cross for condition-matched durations randomly varying from 1500 to 1900 ms.

Procedure

Participants completed the Stroop task in control and hypnosis conditions in counterbalanced order. The experimenter was masked to group identity. Participants were instructed to identify the *color* of the word, while ignoring the *word* itself, by depressing one of three keys on a manual response box. They completed one practice block of 82 trials and seven blocks in each condition. Prior to task onset, participants provided a self-report of current relaxation level (1 = "completely agitated or excited" to 5 = "completely relaxed") to control for differential relaxation across groups (Kirsch & Lynn, 1998). Following completion of the Stroop task, participants rated the frequency with which they used three different strategies (*rehearsal* [repetition of instructions], *experiential* [allowing responses to occur effortlessly], and *positional* [focusing attention on a single letter or portion of a letter]) on five-point Likert scales (1 = "none of the time" to 5 = "all of the time"; Jamieson & Sheehan, 2004; Sheehan et al., 1988). The hypnotic induction and de-induction were drawn from the RSPS II (Weitzenhoffer & Hilgard, 1967), which was modified to exclude all references to relaxation, sleep, and posthypnotic amnesia.

Data Analysis

CVs (SD/M) were computed on the entire data set and, along with relaxation and utilization of the different strategies, were analyzed with mixed-model analyses of variance (ANOVAs) with Condition (control vs. hypnosis) acting as a within-groups variable and Group (LS vs. LDHS vs. HDHS) acting as a between-groups variable. Sequential congruency effects were computed on RT data trimmed of outliers ($M \pm 2$ *SD*s) and restricted to complete alternation trials in which neither the same color word nor ink color was repeated; all error, post-error and negative priming trials were also excluded, resulting in $\sim$42 trials per condition. Analyses of error rates were performed on arcsine-transformed error percentages. Error rate and RT data were analyzed with ANOVAs with Condition, Previous trial (congruent vs. incongruent), and Current trial (congruent vs. incongruent) acting as within-groups variables and Group acting as a between-groups variable. When main effects of Group, or interactions involving Group, were not observed, exploratory ANOVAs collapsing across HS subtypes in the Group variable (LS vs. HS) were conducted; only novel effects are reported for these analyses. Finally, a mixed model analysis of covariance (ANCOVA) controlling for changes in relaxation from the control to the hypnosis condition was performed on RT data to control for differential changes across groups. Significant main effects and interactions were supplemented with *post hoc* Tukey HSD tests or independent or paired-samples t-tests. Pearson correlation coefficients were computed in order to assess the linear relationship between variables.

Results

Relaxation

As can be seen in Table 1, a Condition main effect was found for relaxation, with participants reporting greater relaxation during hypnosis relative to the control condition, $F(1, 45) = 62.43$, $p < .001$, $\eta^2 = .58$. Crucially, the Groups did not differ in relaxation, nor was there a Condition × Group interaction, *F*s < 3. These results indicate that the hypnotic induction did not differentially impact relaxation levels in the three groups.

Strategy Utilization

Utilization of the rehearsal, $F(1, 45) = 9.78$, $p = .003$, $\eta^2 = .18$, and positional strategies, $F(1, 45) = 7.20$, $p = .010$, $\eta^2 = .14$, decreased during hypnosis. In both cases, there were no main effects of Group or Condition × Group interactions, $Fs <$ 2.5. In contrast, participants reported greater use of the experiential strategy during hypnosis, $F(1, 45) = 23.01$, $p < .001$, $\eta^2 = .34$, but again there was no main effect of Group or a Condition × Group interaction, $Fs < 2.5$. An exploratory ANOVA pooling the two HS subtypes found no new effects other than a marginal Condition × Group interaction on utilization of the experiential strategy, $F(2, 45) = 3.85$, $p =$ .056, $\eta^2 = .08$. HS participants displayed a significant increase in utilization of this strategy from the control to the hypnosis condition, $t(28) = 4.43$, $p < .001$, $d =$ 0.85, whereas LS participants did not differ across conditions, $t < 1.5$. These results indicate that utilization of the rehearsal and positional strategies uniformly decreased in all groups following a hypnotic induction, whereas utilization of the experiential strategy increased in HS participants.

Response Automatization

Analysis of CVs revealed a main effect of Condition, $F(1, 45) = 4.65$, $p = .036$, $\eta^2 = .09$, with reduced scores (i.e., greater automatization) following a hypnotic induction (see Table 1). There was no main effect of Group or a Condition × Group interaction, $Fs < 2.5$. An exploratory ANOVA collapsing across HS subtypes, failed to replicate the main effect of Condition, but revealed a marginal Condition × Group interaction, $F(1, 46) = 3.91$, $p = .054$, $\eta^2 = .08$. Subsidiary analyses revealed that CVs did not differ across conditions in the LS participants, $t < 0.5$, but were lower during hypnosis in HS participants, $t(28) = 3.08$, $p = .005$, $d = 0.36$. Further exploratory analyses revealed that decreases in CVs following the hypnotic induction were present in HDHS, $t(10) < 2.68$, $p = .023$, $d = 0.66$, but not LDHS, $t < 1.90$, participants. These findings indicate that a hypnotic induction facilitates narrowing of RT variability among HDHS participants, but not LS and LDHS participants.

Table 1

Descriptive Statistics [M and (SD)] for Self-report and Behavioral Measures as a Function of Condition and Group

	Group					
	LS		LDHS		HDHS	
Variable	Control	Hypnosis	Control	Hypnosis	Control	Hypnosis
Self-report measures						
Relaxation	2.89 (0.66)	4.21 (0.63)	3.28 (0.90)	4.06 (1.00)	3.27 (0.65)	4.82 (0.41)
Rehearsal	2.26 (1.15)	2.05 (1.22)	2.44 (1.38)	1.94 (1.06)	3.09 (1.38)	2.09 (1.22)
Positional	2.32 (1.11)	1.84 (0.77)	2.28 (1.32)	2.28 (1.23)	2.36 (1.69)	1.55 (0.93)
Experiential	3.37 (1.38)	3.68 (1.42)	3.39 (1.10)	4.17 (0.99)	2.55 (1.21)	3.73 (1.10)
Behavioral measures						
CV	0.25 (0.03)	0.25 (0.03)	0.25 (0.04)	0.25 (0.03)	0.27 (0.02)	0.25 (0.03)
RTs (ms)						
CC	524 (97)	544 (82)	557 (84)	576 (96)	554 (40)	587 (86)
CI	565 (105)	597 (79)	612 (108)	642 (124)	642 (40)	649 (110)
IC	533 (92)	549 (85)	563 (93)	594 (96)	574 (55)	617 (87)
II	567 (108)	578 (80)	613 (116)	624 (103)	594 (55)	653 (97)
Errors (%)						
CC	0.04 (0.04)	0.04 (0.03)	0.04 (0.04)	0.05 (0.04)	0.03 (0.04)	0.05 (0.04)
CI	0.05 (0.04)	0.05 (0.05)	0.08 (0.08)	0.05 (0.06)	0.05 (0.05)	0.06 (0.05)
IC	0.04 (0.04)	0.03 (0.04)	0.04 (0.04)	0.04 (0.04)	0.04 (0.04)	0.04 (0.06)
II	0.04 (0.03)	0.04 (0.03)	0.05 (0.04)	0.04 (0.04)	0.05 (0.04)	0.05 (0.04)

Note. LS = low suggestible; LDHS = low dissociative highly suggestible; HDHS = high dissociative highly suggestible; CV = coefficient of variability; CC = congruent-congruent; CI = congruent-incongruent; IC = incongruent-congruent; II = incongruent-incongruent.

Sequential Congruency Effects

No differences in sequential congruency effects were observed according to the order in which the conditions were completed, so data were collapsed across condition orders. Descriptive statistics for sequential congruency effects are presented in Table 1. No evidence for differential speed-accuracy tradeoffs, as reflected in negative correlations between RTs and error rates, was found across conditions or groups. A main effect of Current trial was found for error rates, $F(1, 45) = 17.14$, $p < .001$, $\eta^2 = .28$, with fewer errors on congruent than incongruent trials. No other main effects or interactions on error rates were found, all Fs < 3.

Analysis of RTs revealed a main effect of Condition, $F(1, 45) = 12.47$, $p = .001$, $\eta^2 = .22$, with slower RTs during hypnosis. A main effect of Current trial, $F(1, 45) = 125.33$, $p < .001$, $\eta^2 = .74$, reflecting the Stroop interference effect, was qualified by a Previous trial × Current trial interaction, $F(1, 45) = 39.58$, $p < .001$, $\eta^2 = .47$, reflecting the sequential congruency effect (i.e., reduced Stroop interference following incongruent than congruent trials). Two three-way interactions were observed: Condition × Previous trial × Group, $F(2, 45) = 6.07$, $p = .005$, $\eta^2 = .21$, and Previous trial × Current trial × Group, $F(2, 45) = 4.14$, $p = .022$, $\eta^2 = .16$. These interactions were further mediated by the predicted Condition × Previous trial × Current trial × Group interaction, $F(2, 45) = 4.59$, $p = .015$, $\eta^2 = .17$. This interaction indicates that the impact of the hypnotic induction on sequential congruency effects differed across groups (see Figure 1). An ANCOVA controlling for changes in relaxation from the control to the hypnosis condition replicated all of these effects and revealed no significant effects involving relaxation, all Fs < 1.75.

Subsidiary analyses focused on differences between CI and II trials as an index of conflict-mediated adjustment in control. HDHS participants' RTs were significantly faster for II than CI trials in the control condition, $t(10) = 3.38$, $p = .007$, $d = 1.05$, but non-significantly slower during hypnosis, $t < 0.5$. The RT reduction for II, relative to CI, trials in the control condition ($M = -48.18$, $SD = 47.32$) was significantly greater than in the hypnosis condition ($M = 4.55$, $SD = 32.27$), $t(10) = 2.43$, $p = .035$, $d = 1.37$. This finding supports our central prediction that a hypnotic induction produces a decline in cognitive control among HDHS participants.

The RT patterns of LDHS and LS participants were very similar to one another. Among LDHS participants, II RTs were not faster than CI RTs at baseline, $t < 0.5$, but were suggestively faster during hypnosis, $t = 1.97$, $p = .066$, $d = 0.17$. The RT differences between the control ($M = 1.17$, $SD = 30.53$) and hypnosis ($M = -18.61$, $SD = 40.15$) conditions in this subtype exhibited a weak trend toward significance, $t(17) = 1.94$, $p = .069$, $d = 0.57$. Among LS participants, RTs did not differ between CI and II trials at baseline, $t < 0.5$, but II trials were marginally faster than CI trials during hypnosis, $t(18) = 2.09$, $p = .051$, $d = 0.25$. Improved performance from baseline ($M = 1.95$, $SD = 33.64$) to hypnosis ($M = -19.37$, $SD = 40.31$), however, was not significant, $t < 2$. When LS and LDHS participants were pooled, performance significantly improved from baseline ($M = 1.57$, $SD = 31.72$) to hypnosis

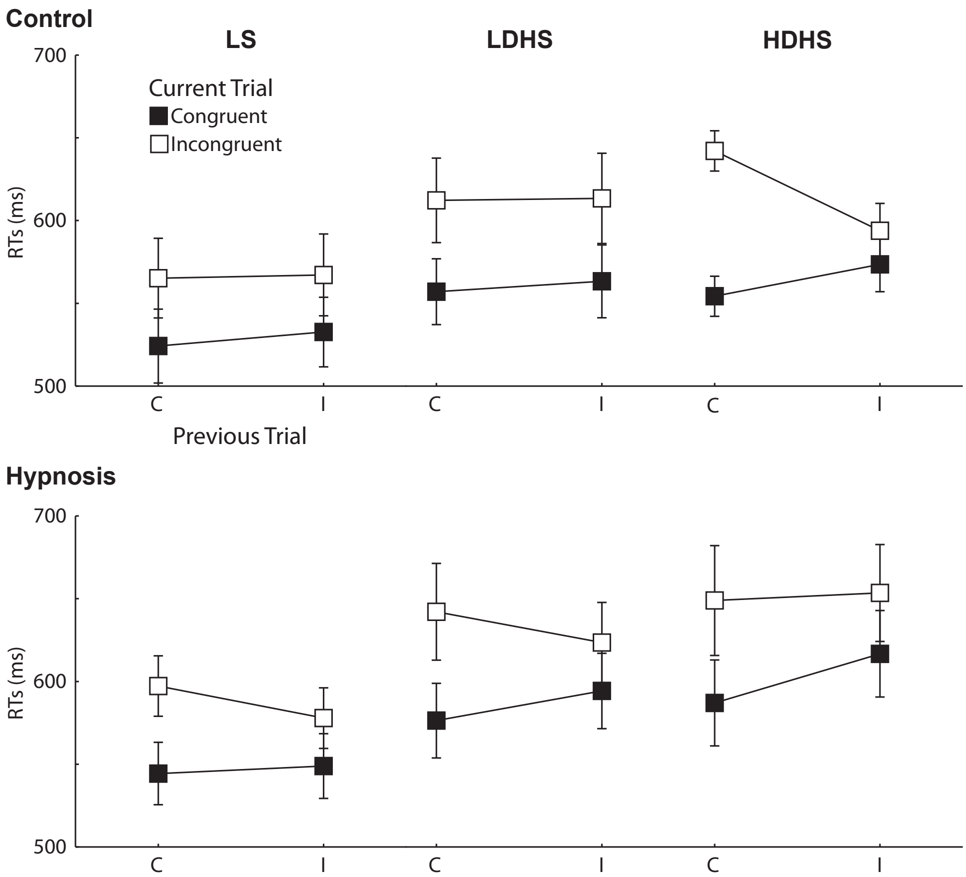

Figure 1. Mean RTs (± *SEM*) in the Stroop color-naming task as a function of Condition, Group (LS = low suggestible, LDHS = low dissociative highly suggestible, HDHS = high dissociative highly suggestible), Previous trial (C = Congruent, I = Incongruent), and Current trial.

($M = -19.00$, $SD = 39.67$), $t = 2.51$, $p = .017$, $d = 0.58$. These results indicate that LS and LDHS participants displayed weak trends toward superior cognitive control following the hypnotic induction.

RT differences between baseline CI and II trials differed as a function of Group, $F(2, 45) = 8.06$, $p = .001$, $\eta^2 = .26$. HDHS participants exhibited superior performance in the control condition than LDHS and LS participants, Tukey HSD ps = .002, who did not differ, $p > .95$. In contrast, RT differences did not differ across groups during hypnosis, $F < 2$. Changes in the RT differences between CI and II trials from the control to the hypnosis condition also differed across groups, $F(2, 45) = 7.26$, $p = .002$, $\eta^2 = .24$. Whereas HDHS participants' performance declined ($M = 52.73$, $SD = 71.99$), that of LS ($M = -21.32$, $SD = 56.54$) and LDHS ($M = -19.78$, $SD = 43.27$) participants improved. This change in conflict adaptation from the control to the hypnosis condition was significantly different between HDHS participants and LS, Tukey HSD $p = .003$, and LDHS, Tukey HSD $p = .004$, participants, who did not differ, $p > .9$. These results demonstrate that HDHS participants exhibited superior cognitive control than LS and LDHS participants at baseline and that a hypnotic induction differentially impacted performance in HDHS participants relative to LS and LDHS participants.

Correlations were computed to examine the relationship between performance across conditions in the three groups. RT differences between CI and II trials at baseline and hypnosis were unrelated in LDHS, $r(18) = .27$, $p = .27$, and LS, $r(19) = -.16$, $p = .51$, but were negatively correlated in the HDHS participants, $r(11) = -.62$, $p = .041$. The correlations of LDHS and HDHS participants were significantly different, $Z = 2.31$, $p = .021$, whereas those of LS and HDHS participants, $Z = 1.32$, $p > .1$, and LS and LDHS participants, $Z = 1.22$, $p > .1$, were not. These relationships indicate that magnitude of cognitive control at baseline among HDHS participants was associated with the magnitude of deterioration in cognitive control during hypnosis, with those individuals exhibiting the greatest conflict adaptation at baseline displaying the poorest adaptation during hypnosis. Insofar as the decline in performance from the control to the hypnosis condition in HDHS participants paralleled the increase in response automatization, as measured by participants' CVs, an additional correlation was computed between the two performance changes. Changes in conflict adaptation from the control to the hypnosis condition were significantly correlated with changes in response automatization, $r(48) = -.35$, $p = .015$, with poorer conflict adaptation during hypnosis associated with increased response automatization.

Correlations were also computed to assess the relationship between dissociative tendencies and performance among LS participants. Dissociation, as measured by the S-DES, was non-significantly positively correlated with RT changes from CI to II trials in the control condition, $r = .34$, and non-significantly negatively correlated in the hypnosis condition, $r = -.14$. The directions of these correlations suggest that high dissociation in LS participants was associated with poorer and greater conflict adaptation in the control and hypnosis conditions, respectively.

Discussion

Analysis of sequential congruency effects in the Stroop task demonstrates that a hypnotic induction differentially impacts cognitive control in different subtypes of HS individuals. Specifically, we found that whereas LS and LDHS participants displayed marginal improvements in conflict adaptation following a hypnotic induction, HDHS participants exhibited a marked deterioration in conflict-mediated adjustment of control. Crucially, this effect cannot be attributed to differential relaxation levels across groups, as was previously suggested (Kirsch & Lynn, 1998), or to differences in strategy utilization. These results are consistent with other studies demonstrating that HS individuals are comprised of distinct subtypes with dissimilar cognitive profiles (Galea et al., 2010; King & Council, 1998; Kunzendorf & Boisvert, 1996; Winkel et al., 2006).

In addition to differential modulation of cognitive control by the hypnotic induction, the two HS subtypes differed in baseline performance. HDHS participants exhibited more pronounced sequential congruency effects at baseline than LDHS and LS participants, who didn't differ from one another. This result suggests that HDHS individuals are better at adjusting attention following response conflict and is consistent with Brown and Oakley's (2004) prediction of superior attention in this subtype. Differential baseline cognitive control across the two subtypes may explain previous inconsistencies in baseline attention in this population (for a review, see Dienes et al., 2009).

The present results are broadly consistent with the position that HS participants are comprised of two subtypes with distinct cognitive and phenomenological profiles (Barber, 1999; Brown & Oakley, 2004; Carlson & Putnam, 1989; Kunzendorf & Boisvert, 1996). In particular, they corroborate the prediction that HDHS participants display impaired cognitive control during hypnosis, whereas LDHS participants maintain flexible use of attention (Brown & Oakley, 2004). This impairment among HDHS participants may reflect a disruption in the coordination of conflict monitoring, as supported by the anterior cingulate, and cognitive control, as supported by the lateral prefrontal cortex, leading to a weakened ability to flexibly adjust control in the wake of response conflict (Egner & Raz, 2007; Jamieson & Woody, 2007). Insofar as predictions generated in the prefrontal cortex regarding the sensory consequences of one's actions play a fundamental role in attributions of agency (Haggard, 2008), impaired cognitive control in HDHS individuals following a hypnotic induction plausibly contributes to inflated involuntariness during hypnotic responding in this subtype relative to LDHS participants (Terhune & Cardeña, in press; Terhune et al., in press).

In demonstrating the differential impact of a hypnotic induction on cognitive control in HS participants, the present findings may help to reconcile a number of competing views in contemporary hypnosis research. First, the performance of the LDHS participants closely corresponds to what would be predicted by social cognitive theories (Lynn et al., 2008), which maintain that a hypnotic induction will not deleteriously affect attention. In contrast, the performance of HDHS participants corresponds to what would be predicted by dissociated control and second-order dissociated control theories (Jamieson & Woody, 2007; Woody & Bowers, 1994). Second, in a similar fashion, the present results may take us one step closer to reconciling the competing positions that hypnosis facilitates (Horton & Crawford, 2004) or impairs (Woody & Sadler, 2008) attention (the marginal improvement among LS participants corroborates a previous finding [Egner et al., 2005]). Whether a hypnotic induction has a facilitative or detrimental effect on cognitive control appears to depend on HS participants' subtype. More broadly, this experiment adds to a series of studies that have documented evidence for two subtypes, one which displays performance that corresponds to the predictions of social cognitive theories and another which displays performance that corresponds to the predictions of dissociation theories (Galea et al., 2010; King & Council, 1998; Terhune et al., in press; Winkel et al., 2006). Further identification of these subtypes and the mechanisms by which they respond to hypnotic suggestions represents an endeavour of critical importance for contemporary hypnosis research.

A limitation of this study is the near absence of high dissociative low suggestible participants. As in other studies (e.g., Butler & Bryant, 1997), dissociation and hypnotic suggestibility were moderately correlated in this sample even though they were measured in independent contexts (see Terhune et al., in press). The absence of this group reduces our ability to discern whether the observed differences between the two subtypes reflect the modulatory influence of dissociative tendencies on individual differences among HS participants or whether they reflect broader covariates of dissociation. However, a number of findings go against the latter interpretation. HDHS participants exhibited superior baseline cognitive control, whereas high dissociative individuals commonly exhibit attentional deficits in control conditions (DePrince & Freyd, 1999; Giesbrecht & Merckelbach, 2009; Giesbrecht, Merckelbach, Geraerts, & Smeets, 2004). This is commensurate with the observed positive, albeit non-significant, correlation demonstrating poorer baseline conflict adaptation among high dissociative LS participants and our own recent finding that high and low dissociative individuals do not exhibit different sequential congruency effects (Terhune, Cardeña, & Lindgren, 2010). The deterioration in cognitive control among HDHS participants following a hypnotic induction is also unlikely to reflect a broader covariate of dissociation. Dissociation was non-significantly associated with improved cognitive control during hypnosis, the converse of what was observed with the HDHS participants. Importantly, in other studies high dissociative LS participants have displayed different response patterns from HDHS participants (King & Council, 1998; Terhune & Cardeña, in press). Finally, even if the observed results are due to broader covariates of dissociation, they still indicate that dissociation modulates individual differences in cognitive control among HS individuals in significant ways and provide robust support for dissociative typological models.

Although we have emphasized the dissimilarities of the two HS subtypes, they exhibited uniformity in their increased utilization of an effortless response strategy (Jamieson & Sheehan, 2004) following a hypnotic induction. This increase may tap into the hypothesized *experiential response set*, a cognitive set characterized by a willingness to allow experiences to occur with minimal effort (Tellegen, 1981). Increased utilization of the experiential response set following a hypnotic induction may be a strategic marker of high hypnotic suggestibility. This finding lends partial support to a componential interpretation of heterogeneity in high hypnotic suggestibility (Laurence et al., 2008; Woody, Barnier, & McConkey, 2005), an alternative to the typological models. This account assumes that HS participants are homogeneous with regard to the core mechanisms underlying high hypnotic suggestibility, but vary in ancillary componential abilities, which contribute to individual differences in cognitive functioning and hypnotic responding. According to this account, the uniform heightened adoption of the experiential set by HS participants during hypnosis may partly reflect the core ability underlying high hypnotic suggestibility, whereas differential cognitive control at baseline and following a hypnotic induction may represent an ancillary componential ability that influences other features of hypnotic responding such as involuntariness. However, the effect sizes for the differences in experiential strategy utilization between LS and HS participants are small in comparison to those for the differential sequential congruency effects between the LDHS and HDHS subtypes, whereas the converse would be expected by this account. Nevertheless, the componential model remains a viable alternative to the typological models and is worthy of further theoretical development and investigation.

Acknowledgments

This research was supported by Research Bursary 54/06 from the Bial Foundation to D.B.T. and E.C. and the David Caul Graduate Research Award from the International Society for the Study of Dissociation to D.B.T.

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