CORTEX 49 (2013) 463–473

Available online at www.sciencedirect.com

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Special issue: Research report

Using suggestion to modulate automatic processes: From Stroop to McGurk and beyond

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ARTICLE INFO

Article history:
Received 1 January 2012
Reviewed 1 April 2012
Revised 17 May 2012
Accepted 10 August 2012
Published online 10 September 2012

Keywords:
Attention
Suggestion
Hypnosis
Automatic process
Self-regulation

ABSTRACT

Cognitive scientists typically classify cognitive processes as either controlled or automatic. Whereas controlled processes are slow and effortful, automatic processes are fast and involuntary. Over the past decade, we have propelled a research trajectory investigating how top-down influence in the form of suggestion can allow individuals to modulate the automaticity of cognitive processes. Here we present an overarching array of converging findings that collectively indicate that certain individuals can derail involuntary processes, such as reading, by "unringing" the proverbial bell. We examine replications of these effects from both our own laboratory and independent groups, and extend our Stroop findings to several other well-established automatic paradigms, including the McGurk effect. We thus demonstrate how, in the case of highly suggestible individuals, suggestion seems to wield control over a process that is likely even more automatic than the Stroop effect. Finally, we present findings from two novel experimental paradigms exploring the potential of shifting automaticity in the opposite direction – i.e., transforming, without practice, a controlled task into one that is automatic. Drawing on related evidence from the neuroscience of contemplative practices, we discuss how these findings pave the road to a more scientific understanding of voluntary control and automaticity, and expound on their possible experimental and therapeutic applications.

1. Introduction

Cognitive scientists typically categorize mental processes on a spectrum ranging from controlled to automatic. Whereas controlled processes are voluntary, slow, and effortful, automatic processes are involuntary, fast, and effortless (Shiffrin and Schneider, 1977). Achieving literacy, for example, is a controlled and deliberate process, which requires resources and attention. Once learned and sufficiently practiced, however, reading takes on the qualities of an automatic process, proceeding quickly and without effort (MacLeod, 1992). A common view posits that controlled processes can become deeply ingrained as result of considerable practice (MacLeod and Dunbar, 1988). Once automatized, moreover, these processes appear resistant to control and largely imperturbable. According to this view, therefore, automatization seems to entrench the process and recast it as difficult – if not downright impossible – to undo (e.g., you cannot unring a bell

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http://dx.doi.org/10.1016/j.cortex.2012.08.007

that has rung). While many researchers have investigated how controlled processes may become automatic, only a few recent reports have examined whether and how automatic processes can de-automatize and return into the purview of control (Raz and Buhle, 2006).

Over the past decade, we have propelled a research trajectory investigating how atypical attention, in the form of hypnotic, posthypnotic, and nonhypnotic suggestion, can allow individuals to modulate the automaticity of cognitive processes. We have demonstrated that altered planes of attention can unring the proverbial bell, derailing processes previously considered ballistic and impervious to willful intervention, such as reading (e.g., Raz and Campbell, 2011; Raz et al., 2002). Although some researchers were able to elicit such de-automatization in individuals but found the wholesale effect more elusive, we, together with several independent groups, have reported numerous replications of these experimental findings. Recent neuroimaging assays have begun to unravel the mechanisms of de-automatization and suggestion (Casiglia et al., 2010; Raz et al., 2005; Terhune et al., 2010), while behavioral accounts have expanded the scope and generalizability of these findings (Augustinova and Ferrand, 2012; Iani et al., 2006, 2009; Parris et al., 2012; Raz et al., 2006). Here, we outline this course of research and report data from three novel experimental paradigms that push the boundaries of modulating automaticity. We review these findings and discuss their implications for the scientific understanding and applications of automaticity and cognitive control.

2. Suggestion overrides the Stroop effect

The Stroop paradigm constitutes a robust experimental demonstration of automaticity. It reveals the involuntariness of reading – proficient readers find it difficult to withhold accessing word meaning regardless of instructions to attend to ink color only (Stroop, 1935). When the ink color and the color word are incongruent (e.g., the word BLUE inked in red), participants are generally slower and less accurate to name the ink color compared to when stimuli are either congruent (e.g., the word RED inked in red) or neutral (e.g., the word LOT inked in red). The difference between responses to congruent and incongruent trials makes up the Stroop effect. One of the most widely studied tasks in the attention literature, the Stroop paradigm constitutes the "gold standard" of automatic tasks (MacLeod, 1991). The word-color interference effect illustrates how processing of irrelevant information takes place even when it is unfavorable to the task at hand. Because the Stroop effect is a ballistic attentional phenomenon that persists despite repeated exposure, most cognitive scientists concur that processing printed linguistic stimuli is inevitable for skilled readers (MacLeod, 1992).

The Stroop paradigm provides a useful vehicle for studying the influence of suggestion on automatic processes. A number of reports have challenged the automaticity of the Stroop effect, demonstrating significant reduction of Stroop interference as a function of specific instructions or context manipulations (Besner, 2001; Besner and Stolz, 1999a, 1999b, 1999c; Besner et al., 1997; Dishon-Berkovits and Algom, 2000; Kuhl and Kazén, 1999; Long and Prat, 2002; Melara and Algom, 2003; Pansky and Algom, 2002; Sharma et al., 2010; Goldfarb et al., 2011). Despite selective criticisms (Neely and Kahan, 2001), these collective findings intimate that factors such as memory, emotion, and attention may influence automatic processing in Stroop-like situations. Thus, we wanted to see whether a posthypnotic suggestion for alexia – asking participants to view word stimuli as meaningless symbols of a foreign language – could derail a classic Stroop effect in highly suggestible individuals.

Increasingly prominent in cognitive neuroscience, hypnosis refers to an altered plane of awareness characterized by attentive-receptive concentration and heightened response to suggestion (Oakley and Halligan, 2009; Raz and Shapiro, 2002). Brief verbal suggestions can allow highly hypnotic suggestible individuals (HHSs) to show profound alterations in their perception, emotion, thought, and action, including experiencing visual hallucinations and relinquishing control over voluntary motor actions (Kihlstrom, 2008). Although hypnotic induction procedures typically lead to slight increases in suggestibility, HHSs often respond similarly to suggestions in the absence of a formal induction (for a discussion on the definition of hypnosis in light of such caveats, see Kirsch et al., 2011). Posthypnotic suggestion refers to a condition following termination of the hypnotic experience, wherein a pre-arranged cue prompts subjects to alter their behavior or perception in response to a suggestion made during the hypnotic episode. By obviating confounding factors associated with the hypnotic ritual, posthypnotic suggestion provides a particularly potent instrument for elucidating the processes underlying common waking consciousness and cognition (Raz, 2004).

Our findings demonstrate that a specific suggestion to see word stimuli as meaningless symbols can significantly reduce (Raz and Campbell, 2011; Raz et al., 2005, 2006, 2007b) and, in some cases, may even eliminate[1] (Raz et al., 2003, 2002) the Stroop effect. Several follow-up studies elucidate the potential mechanisms subserving this modulation. A dramatic change in optical accommodation constitutes one possible means by which suggestion might influence typical Stroop results. According to this view, suggestion may alter the muscle tone and resting state of the eye and consequently dampen visual input. This perspective is incongruent with the results of a study using a pharmaceutical agent to induce cycloplegia – paralysis of the ciliary muscles of the eye – which replicated the influence of suggestion on Stroop interference even when researchers controlled for optical accommodation (Raz et al., 2003). Findings from a brain imaging study combining functional magnetic resonance imaging (fMRI) and event-related potentials (ERP), however, indicated that suggestion produced a generalized dampening in extra-striate regions, rather than a selective modulation of orthographic processing (Raz et al., 2005). Thus, it appears that the suggestion, rather

[1] Although limited statistical power prevents us from concluding formal elimination of Stroop interference, we loosely refer to elimination when, following suggestion, Stroop interference (i.e., incongruent reaction time minus neutral reaction time) was significantly smaller than without suggestion ($p < .05$) and did not differ significantly from zero.

than altering the physical properties of the stimulus on the retina, modulates Stroop performance through an early top-down dulling of visual information. Complicating this view, however, a recent behavioral account reported that the alexia suggestion reduced interference on a standard Stroop task but did not influence performance on a "semantic" variant of the task (i.e., incongruent stimuli composed of a color-associated word – e.g., "sky" – printed in an incongruent color – e.g., in this case, green) (Augustinova and Ferrand, 2012). On one hand, the absence of a selective effect on semantic activation coheres with the aforementioned neuroimaging findings indicating that the influence of suggestion was not specific to orthographic processing (Raz et al., 2005). On the other hand, the previously observed generalized dampening of early visual information (Raz et al., 2005) would lead naturally to the prediction that the suggestion should reduce interference in both standard and semantic Stroop tasks. Future studies exploring these nuances, therefore, would be necessary to elucidate at what stage in the processing hierarchy the suggestion takes effect.

Recently, we investigated the effects of negative priming (NP) in a Stroop paradigm to further tease apart the mechanisms of de-automatization (Raz and Campbell, 2011). NP is a robust measure consisting of a pair of trials wherein the ink color of the current stimulus is identical to the word ignored in the immediately preceding stimulus. In such trial pairs, participants typically respond more slowly than usual on the second trial because they must provide the particular color response that they had to inhibit on the preceding trial (Mayr and Buchner, 2007; Neill, 1977). We predicted that post-hypnotic suggestion would reduce NP in HHSs compared to less hypnotically suggestible individuals (LHSs). NP is an advantageous supplementary index to Stroop performance because it is largely immune to volitional strategies that participants may adopt, and because influencing a stepwise procedure is extremely difficult to manage consciously (Tipper, 2001). We found that although suggestion reduced the Stroop effect in a large cohort, it hardly affected NP. Limited statistical power, however, likely restricted the sensitivity of our analysis, and we are currently examining this issue further by triangulating findings from converging imaging domains. Future studies probing NP would likely shed light on the cognitive underpinnings of altered Stroop performance as a function of suggestion (MacLeod, 2011; Campbell and Raz, 2012).

In addition to our own studies (Raz and Campbell, 2011; Raz et al., 2005, 2003, 2007b, 2002), multiple independent reports have confirmed that suggestion can reduce Stroop interference in HHSs (see Campbell et al., 2012; Augustinova and Ferrand, 2012; Casiglia et al., 2010; Parris et al., 2012; Raz et al., 2006; Sun, 1994). Table 1 provides a summary of the methods and findings of these various accounts (for a discussion of possible sources of outcome variability, see Raz et al., 2007b). A replication study conducted in an independent laboratory at the University of Connecticut extended our findings by showing that nonhypnotic suggestion (i.e., in the absence of a formal induction procedure) produced improvements in Stroop performance equivalent to those achieved with posthypnotic suggestion (Raz et al., 2006). Recent studies from independent research groups (Augustinova and Ferrand, 2012), including an as yet unpublished manuscript (Parris and Dienes, under review), corroborate the notion that suggestion can reduce Stroop interference in HHSs even outside of a hypnosis context. In addition, anecdotal case reports (MacLeod and Sheehan, 2003; Schatzman, 1980) and unpublished informal accounts (e.g., Thalia Wheatley, personal communication, 2002; Stanley Fisher, personal communication, 2000) support the removal of the Stroop effect among specific individuals. Thus, converging evidence demonstrates the influence of suggestion on Stroop performance and intimates that such effects may extend beyond the domain of hypnosis.

Independent studies indicate that suggestion may govern additional automatic processes besides the Stroop effect. For example, posthypnotic suggestion improved performance on two classic visual attention paradigms probing involuntary response conflict: the Flanker (Iani et al., 2006) and Simon (Iani et al., 2009) tasks. One of these accounts, moreover, showed that a comparable nonhypnotic suggestion hardly influenced the Flanker effect (Iani et al., 2006). Differences in wording between the posthypnotic and nonhypnotic suggestions, however, may explain why this study failed to show an effect of nonhypnotic suggestion whereas other studies have demonstrated such effects using a Stroop paradigm (Augustinova and Ferrand, 2012; Raz et al., 2006; Parris and Dienes, under review). Further extending the potential of de-automatization, a recent study used posthypnotic suggestion to override perceptual integration in a single highly hypnotically suggestible face-color synesthete, eliciting concomitant alterations in her ERP profile (Terhune et al., 2010). Thus, the potential to unring the bell using suggestion seems to generalize beyond the Stroop effect and offers intriguing prospects for further cognitive and applied investigations.

3. Gaining control over increasingly automatic processes: from Stroop to McGurk

How far can we push the apparent ability of HHSs to override automatic processes? We asked this question using the classic McGurk effect – an auditory illusion, crafted by presenting visual and auditory streams that are incongruent, demonstrating the influence of visual facial movements on speech perception (McGurk and MacDonald, 1976) (see Fig. 1, Panel A). The McGurk effect is a well-documented and strongly automatic perceptual phenomenon (Colin et al., 2002; Soto-Faraco et al., 2004). Neither practice (Summerfield and McGrath, 1984) nor knowledge of the dubbing (McGurk and MacDonald, 1976) reduces the effect. Moreover, electrophysiological findings reveal that the perceptual integration of the McGurk effect begins at the level of primary auditory cortex (Kislyuk et al., 2008). Consequently, researchers consider the McGurk effect robust, inexorable, and largely immune to top-down influences. This effect, furthermore, is arguably more automatic than the Stroop effect because, apparent in non-human primates (Ghazanfar and Logothetis, 2004) and starting earlier in life than visual word reading (Rosenblum et al., 1997), audiovisual integration of vocal percepts is likely more deeply ingrained than processing visual word-forms. We wanted to examine whether a specific posthypnotic

Table 1 – Summary of studies demonstrating reduced Stroop interference and related de-automatization effects as a function of suggestion.

	Type of suggestion	N	Methods	Findings
Stroop studies conducted by Raz				
Raz et al., 2002	Posthypnotic	32	Behavioral	Following suggestion, Stroop interference among HHSs did not differ significantly from zero, intimating complete elimination of Stroop interference
Raz et al., 2003	Posthypnotic	12	Cycloplegia – paralysis of the ciliary muscles of the eye	Preventing optical accommodation did not hinder the ability of suggestion to seemingly eliminate Stroop interference
Raz et al., 2005	Posthypnotic	16	Combined fMRI and ERP	Reduced Stroop interference was accompanied by a generalized dampening of early visual information (decreased amplitude of the N100 and P100 components) and reduced conflict processing (diminished fMRI signal in the ACC)
Raz et al., 2007b	Posthypnotic	49 (HHSs only)	Behavioral	Suggestion significantly reduced Stroop interference
Raz and Campbell, 2011	Posthypnotic	83 (re-analysis of data from Raz et al. (2007), with additional data from 34 LHSs)	Behavioral, NP	Suggestion reduced Stroop interference in HHSs and to a lesser extent in LHSs, but hardly influenced the NP effect
Independent replications				
Schatzman, 1980	Hypnotic	1	Clinical case study	A suggestion to regress back to the age of three reduced the Stroop effect
Sun, 1994	Hypnotic and nonhypnotic	24	Behavioral	Hypnotic, but not nonhypnotic, suggestion reduced Stroop interference
MacLeod and Sheehan, 2003	Hypnotic	1	Laboratory case study	A suggestion administered during hypnosis eliminated Stroop interference in a single HHS
Raz et al., 2006 (although Raz provided the main impetus behind this study, an independent group of researchers at the University of Connecticut collected and analyzed the data)	Posthypnotic and nonhypnotic	25 (HHSs only)	Behavioral	Nonhypnotic suggestion reduced Stroop interference comparably to posthypnotic suggestion
Casiglia et al., 2010	Posthypnotic	12	ERP, cardiovascular monitoring	Improved Stroop performance was accompanied by reduced reflexive vasoconstriction and increased amplitude of a late fronto-parietal brain potential
Augustinova and Ferrand, 2012	Nonhypnotic	Experiment 1: 28 Experiment 2: 15	Behavioral, including "semantic Stroop" task	Suggestion reduced the Stroop effect on a standard Stroop task but not on a "semantic" variant of the Stroop task
Parris et al., 2012	Posthypnotic	19 (HHSs only)	Behavioral	Suggestion reduced the Stroop effect only on trials with short stimulus-response intervals
Parris and Dienes, under review	Nonhypnotic	24 (8 HHSs, 8 LHSs, 8 medium hypnotically suggestibles)	Behavioral	Nonhypnotic suggestion reduced the Stroop effect

Table 1 – (*continued*)

	Type of suggestion	N	Methods	Findings
Conceptual replications				
Iani et al., 2006	Posthypnotic and nonhypnotic	16	Behavioral, Flanker task	Only posthypnotic suggestion reduced the Flanker compatibility effect. Differences in wording may account for why the nonhypnotic suggestion hardly influenced performance
Iani et al., 2009	Posthypnotic	28	Behavioral, Simon task	Suggestion significantly reduced the interference of task-irrelevant arrow stimuli on a Simon task
Terhune et al., 2010	Posthypnotic	1	ERP, perceptual integration in synesthesia	Suggestion diminished behavioral and ERP markers of face-color response conflict in a single highly hypnotically suggestible synesthete.

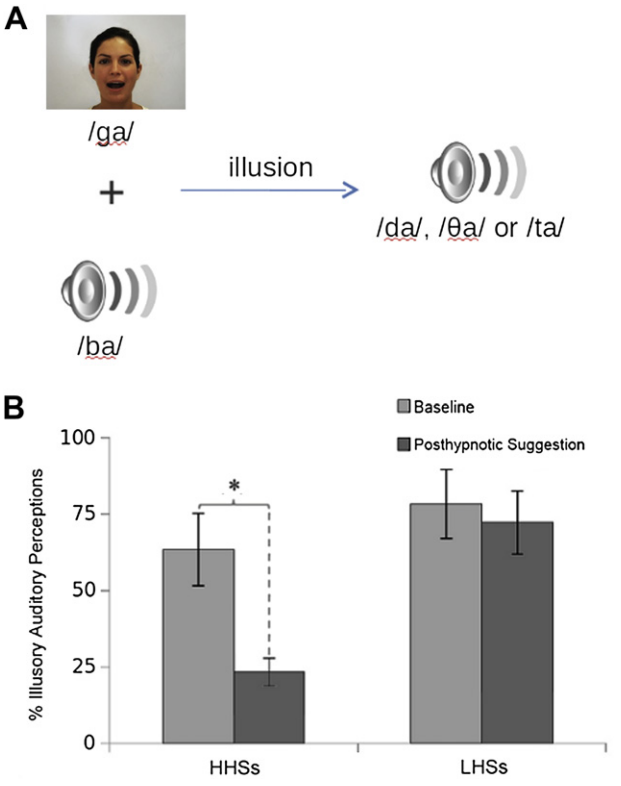

Fig. 1 – Posthypnotic suggestion derails the McGurk effect. A. The McGurk task involves watching a video of a speaker uttering syllables. In some trials, the syllable mouthed by the speaker, such as /ga/, is dubbed with incongruent audio, such as /ba/. In this particular case, the participant would usually report hearing /da/, a fusion between the phonemes /va/ and /ba/. Alternatively, the visual percept sometimes completely overrides the audio component, referred to as visual capture. B. Following a posthypnotic suggestion to perceive the audio and video components of the stimuli as distinct information streams, HHSs but not LHSs fell for fewer illusory auditory perceptions. Error bars represent standard error.*: $p < .05$.

suggestion could reduce illusory speech sounds and improve correct auditory identifications on the McGurk task.

We conducted a pilot study investigating whether suggestion could reduce the McGurk illusion in 12 healthy volunteers, following an experimental design similar to that used in previous Stroop studies with suggestion (e.g., Raz et al., 2002). We screened participants for hypnotic suggestibility using both the Harvard Group Scale of Hypnotic Susceptibility, Form A (HGSHS:A; Shor and Orne, 1962) and the Stanford Hypnotic Susceptibility Scale, Form C (SHSS:C; Weitzenhoffer and Hilgard, 1962). Using a counterbalanced order, we ran six HHSs (scoring 10–11 out of a possible 11 on the SHSS:C; top 5% of HGSHS:A) and six LHSs (scoring 0–1 of a possible 11 on the SHSS:C; bottom 5% of HGSHS:A) on a standard McGurk paradigm under two conditions. In one condition we provided all participants with a posthypnotic suggestion to view the auditory and visual components of the audiovisual stimuli as disparate information streams, exhorting priority to the auditory input while crisply viewing the visual information. In the other condition we provided no suggestion. After each trial, participants reported the speech sound that they had heard. As in each of the following pilot studies, an experimenter was present at all times to monitor ocular stance and direction of gaze.

Sitting at a chinrest-headrest setup, participants viewed stimuli from a distance of 52 cm. A flat screen and two adjacent loudspeakers delivered the audiovisual information. Each McGurk session included a random order of 30 incongruent and 40 congruent trials. During each trial, a video clip presented the face of a female English speaker pronouncing consonant-vowel syllables. Congruent audiovisual stimuli (/ba/, /da/, /ga/, and /va/) consisted of audio of a consonant-vowel coupled with video of the same consonant-vowel. Incongruent audiovisual stimuli consisted of auditory /ba/ dubbed over visual /va/, /da/, or /ga/.

We calculated the proportion of illusory auditory perceptions on incongruent trials, for each group – HHSs or LHSs – both with and without posthypnotic suggestion. Experimental order – whether participants experienced suggestion first or second – was not significant. A 2 × 2 repeated-measures

ANOVA yielded a significant interaction between group and suggestion for the proportion of total auditory illusions ($F_{1,10} = 6.272$, $p < .05$, $\eta^2 = .227$). Planned comparisons revealed that following a posthypnotic suggestion to construe the audio and video components of the audiovisual stimuli as separate information streams, HHSs fell for fewer auditory illusions ($t_5 = 3.487$, $p < .05$, $\eta^2 = .709$) while the performance of LHSs did not change significantly (Fig. 1). Thus, suggestion appears to reduce the McGurk effect in HHSs.

In a follow-up study, we leveraged the McGurk de-automatization paradigm to test an influential theory of hypnosis that views expectations as a primary determinant of hypnotic suggestibility (Lifshitz et al., 2012a). In this study, we tested only participants who were unscreened for hypnotic suggestibility. We experimentally modified expectations to convince participants that they could respond strongly to suggestions for changes in their perception. Regardless of heightened expectation, however, we found no group effects indicating that these unscreened participants were able to override the McGurk effect following suggestion. These findings intimate that expectation alone is insufficient to promote responses associated with high hypnotic suggestibility, including overriding the automaticity of the McGurk effect.

Altogether, our preliminary findings with the McGurk effect intimate that a specific posthypnotic suggestion can alter the ballistic nature of a highly automatic effect in HHSs but not less suggestible participants. At least for HHSs, therefore, deeply ingrained mental operations – potentially even more involuntary than the Stroop effect – may be more controllable than previously presumed.

4. Moving in the opposite direction: can suggestion "automatize" effortful processes without practice?

At least for some individuals, suggestion seems capable of shifting certain automatic processes back into the purview of control. Little is known, however, about the influence of top-down mechanisms on the automatization of controlled processes. Extended exposure or practice is capable of propelling some controlled processes into the realm of automatic performance (e.g., a neophyte becoming a proficient reader). On the other hand, our research with the Stroop and McGurk effects indicates that specific suggestions can obviate automatic processes, including turning a proficient reader into an ostensible analphabet (e.g., Raz et al., 2002; see Section 2 above). To further explore these nuances, we have initiated a related yet distinct research trajectory investigating whether suggestion can shift cognitive processes in the opposite direction – i.e., from controlled to automatic – without extensive practice. Preliminary support for this prospect comes from a study by Cohen Kadosh et al. (2009), which reported that a posthypnotic suggestion engendered digit-color synesthesia effects in HHSs by facilitating cross-modal perceptual integration (Cohen Kadosh et al., 2009). We are presently exploring the potential of inducing automaticity by investigating the influence of suggestion on two robust and well-studied cognitive processes: motion perception and visual search.

4.1. *The masked diamond paradigm (MDP)*

To explore the use of hypnotic suggestion in automatizing a controlled process, we adapted the MDP – a well-documented visual task in which an absence of critical visual information suffices to transform an otherwise easy task into a difficult, even intractable, one (Lorenceau and Shiffrar, 1992; McDermott et al., 2001). Specifically, we are currently examining whether suggesting the presence of critical visual occluders – necessary for automatic perceptual processing in the MDP – could convert an effortful task into one that is effortless.

The MDP requires participants to identify the direction of moving geometric figures (e.g., clockwise, counterclockwise) with invisible apexes. When a visual mask occludes the invisible apexes, motion detection is immediate and effortless; without the occluding masks, however, determining the direction of motion is difficult (see http://razlab.mcgill.ca/demomotrak.html). Based on the MDP, we designed a 10-min behavioral assessment to measure accuracy and reaction time. Emphasizing both speed and accuracy to all participants, a computer program introduced the task through a brief interactive demonstration featuring trials with and without occluders. The program recorded reaction time and accuracy and provided feedback (correct or incorrect) on six training trials, followed by 72 experimental trials containing neither feedback nor occluders. Our pilot study included eight HHSs (scoring 9–12 on the HGSHS:A) and nine LHSs (scoring 0–3 on the HGSHS:A) who completed the task on two occasions – baseline and, approximately 1 week later, following a brief live hypnotic induction and a specific suggestion to visualize imaginary (i.e., non-existent) visual occluders that would allow rapid and accurate performance. Following the hypothesis that hypnotic suggestion is capable of automatizing a difficult controlled process, we expected HHSs, more than LHSs, to show faster reaction times and improved accuracy as a function of suggestion (Fig. 2).

A 2 × 2 repeated-measures ANOVA yielded a significant interaction ($F_{1,15} = 8.319$, $p < .05$; $\eta^2 = .287$) between suggestion and group for accuracy scores (i.e., percent correct). In addition, we found a marginally significant main effect of suggestion on mean reaction times ($F_{1,15} = 3.913$, $p = .067$; $\eta^2 = .207$). Of importance, planned comparisons showed that HHSs but not LHSs performed the task with greater accuracy following suggestion ($t_7 = -5.709$, $p < .001$, $\eta^2 = .823$), intimating that they successfully visualized the occluding masks. These early findings support the notion that suggestion may allow specific individuals to recruit cognitive processes (i.e., visualization) that are ordinarily less accessible to conscious will. By rendering a difficult task easier, therefore, suggestion appears to bridge the gap toward automaticity.

4.2. *Pop out in visual search*

Visual search provides another useful vehicle for investigating whether atypical attention can transform a typically effortful process into one that is more automatic. In classical visual search tasks, target objects usually elicit "pop-out" effects if they display salient features (e.g., bright colors or bold shapes) that are absent in distractor objects. The unique feature of the

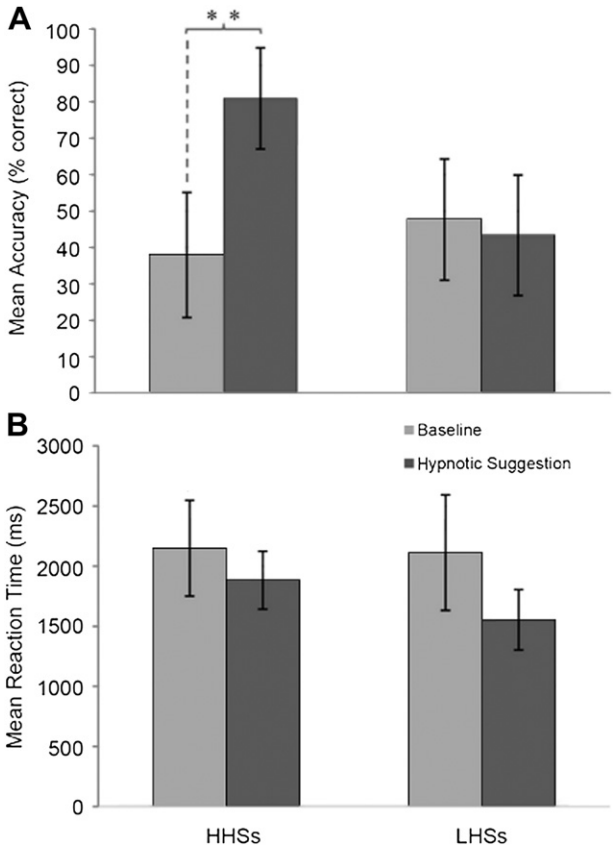

Fig. 2 – Suggestion improves reaction time and accuracy on the masked diamond task. A. A suggestion to hallucinate the critical visual occluders led to more accurate responses among HHSs but not LHSs. B. Although reaction time did not differ significantly between conditions, our data intimate a general trend toward faster responses following suggestion. Error bars represent standard error. **: $p < .001$.

target guides attention automatically so that one immediately notices its presence (Wolfe and Horowitz, 2004). We can observe differences in visual search tasks by analyzing both efficiency in search time and the relationship between search time and the number of objects present in the display (set size). Visual search paradigms that showcase salient target features and elicit pop-out effects typically generate faster search times and a weaker relationship between set size and search speed (Treisman et al., 1992). When pop out is absent the visual search reflects a serial task – the participant must consciously scan all objects in the display. With pop out, however, the search becomes a parallel, pre-attentive, task and is largely unaffected by the number of distractor objects (Treisman and Gelade, 1980).

Behavioral (Smilek et al., 2006) and eye-tracking (Watson et al., 2010) studies report that top-down processes (e.g., specific cognitive strategies) may influence performance on visual search tasks. Compared to actively scanning for the target, attending passively – i.e., relaxing and allowing the target to pop out on its own – seems to promote efficient visual search (Smilek et al., 2006). Eye-tracking during visual search, moreover, reveals distinct oculomotor patterns associated with "active scanning" versus "passive attendance" (Watson et al., 2010). Improved performance may reflect the relaxation of executive processes manifest in active search that inhibit automatic sequences from guiding attention to salient pop-out features (Smilek et al., 2006). Thus, we hypothesized that a specific top-down modulation in the form of suggestion would improve the efficiency of visual search.

To investigate whether posthypnotic suggestion can modulate the automaticity of visual search and promote pop-out effects among HHSs, we conducted a preliminary study testing six HHSs (scoring 9–11 on the SHSS:C; top 5% of HGSHS:A) and six LHSs (scoring 0–2 on the SHSS:C; bottom 5% of HGSHS:A) on three categories of visual search tasks adapted from Treisman and Gelade (1980). The three tasks were (1) search for a target "O" or "T" among distractor "Q"s or "L"s, respectively; (2) search for a particular colored letter among distractors that match either the target letter or the target color; and (3) search for a letter among digits. Each task contained two trial types (target present and target absent) and two set sizes (6 objects and 16 objects) pseudo-randomly intermixed with an equal ratio. Seated at a chinrest and viewing stimuli on a flat panel display, participants were instructed to indicate via keypress as quickly and accurately as possible whether the target was present or absent.

Following a posthypnotic suggestion to see the target pop out effortlessly from the distractors, HHSs displayed a significantly shallower slope of the search times between the two set sizes when averaging across all visual search tasks and trial types ($F_{1,10} = 6.17$, $p < .05$). These results indicate that the number of distractors generally exerted less influence over the efficiency of the search. In addition, following suggestion HHSs demonstrated significantly faster search times across tasks and trial types ($F_{1,10} = 18.62$, $p < .01$). Fig. 3 shows preliminary results from the three tasks for HHSs, at baseline and following the posthypnotic suggestion for visual pop out. These early findings, together with the abovementioned research on motion perception, support the prospect of using suggestion to improve performance on effortful tasks and perhaps render these processes more automatic without extensive exposure or practice.

5. Discussion

Here we show that, under certain conditions and using a specific population, suggestion appears to modulate the automaticity of cognitive processes. Extending our research from Stroop to McGurk, we present preliminary findings showing that specific suggestions may allow HHSs to override involuntary audiovisual integration in speech perception, a process likely even more ballistic than Stroop word reading. Furthermore, we report pilot findings indicating that top-down influences could potentially regulate automaticity in the opposite direction – shifting effortful processes, including obscured motion perception and inefficient visual search, toward more effortless computations. The present paper offers illustrative sketches of these ongoing research efforts, and we hope to soon publish comprehensive experimental reports on these themes. Moreover, while we have considered

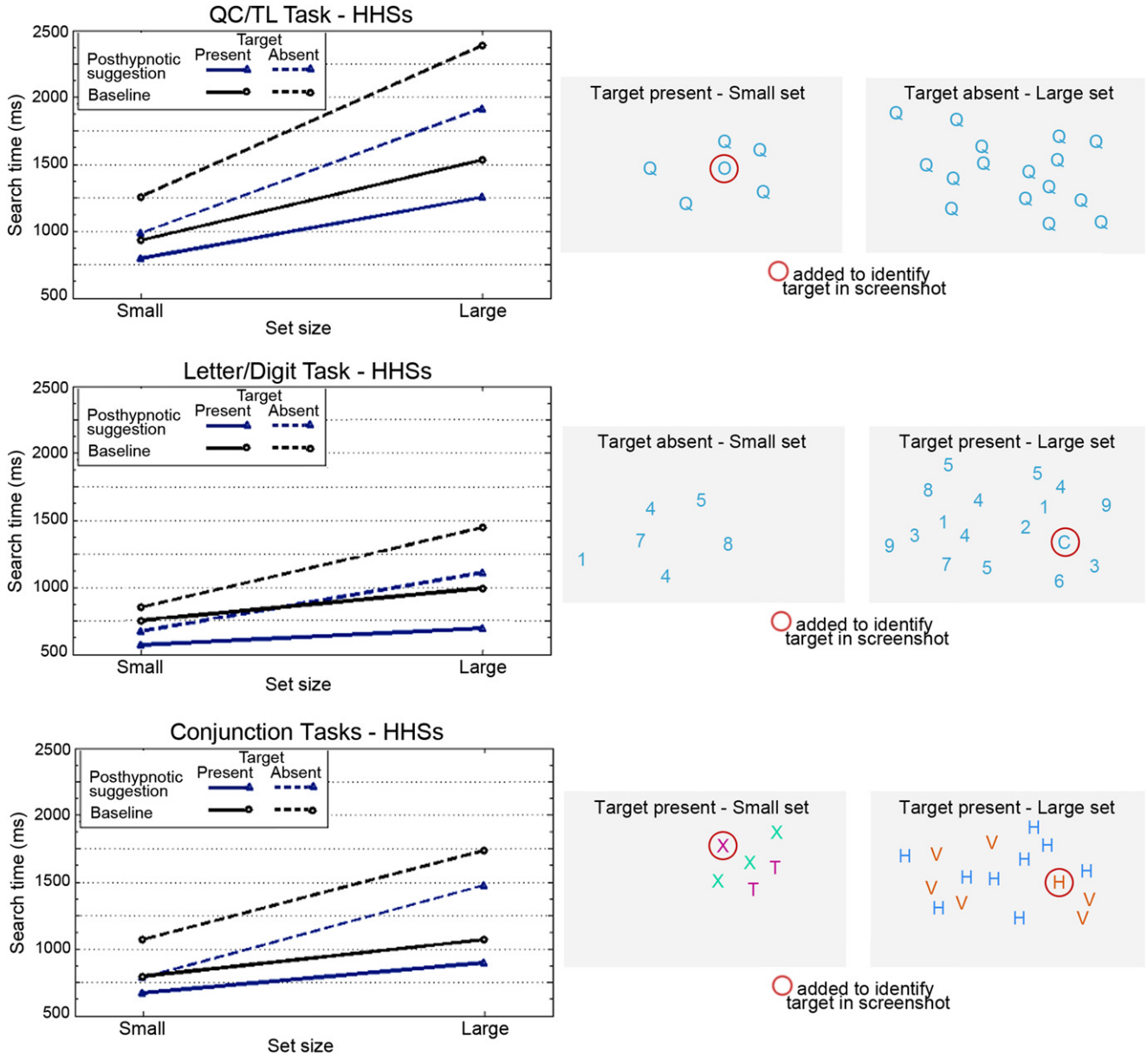

Fig. 3 – Posthypnotic suggestion automatizes pop out in visual search. Following a posthypnotic suggestion to see the target pop out from the distractors, HHSs demonstrated a significantly shallower slope of the relationship between search times and set size across all visual search tasks and trial types ($p < .05$). Compared to baseline, moreover, the suggestion produced significantly faster search times among HHSs ($p < .01$).

these effects within a specific theoretical framework pertaining to involuntary processes, alternative perspectives on automaticity may provide additional prospects for interpreting these data (e.g., Moors and De Houwer, 2006). Regaining control over an automatic process, or vice versa, holds fundamental implications for clinical interventions and paves the road to a more scientific understanding of volitional control in health as well as in pathology.

Recent accounts report reduction in the frequency and intensity of tics in individuals diagnosed with Tourette's syndrome following behavioral interventions using variations of suggestion to address the largely involuntary nature of such tics (Piacentini et al., 2010; Raz, 2012; Raz et al., 2007a, 2009; Woods et al., 2011). These behavioral approaches for managing Tourette's syndrome – including function-based and habit-reversal training interventions – use the power of verbal suggestion and instruction to invoke tangible mind-body regulation. In addition to underscoring an evidence-based nonpharmacological intervention, these studies employ a supportive psychotherapy and education control treatment as "placebo" comparators – an improvement over many studies of psychotherapeutic interventions that use only no treatment or wait-list controls. Such research efforts carefully navigate the psychology–biology interface while highlighting the applied and therapeutic potential of de-automatization.

Other forms of atypical attention, including various contemplative practices, may provide additional means of gaining control over automatic processes (Lifshitz et al., 2012b). For example, specific meditative practices appear to override habitual neural responses associated with spontaneous semantic thought (Pagnoni et al., 2008), involuntary emotional reactivity (Farb et al., 2010; Taylor et al., 2011), and pain perception (Brown and Jones, 2010; Gard et al., 2011; Grant et al., 2011; Zeidan et al., 2011). Recent accounts, moreover, indicate that certain forms of meditation may derail the mind's tendency to wander to task-unrelated thoughts (Mrazek et al., 2012), perhaps by altering activity among resting state networks of the brain including the default mode network (Brewer et al., 2011; Farb et al., 2007; Hasenkamp and Barsalou, 2012; Jang et al., 2011; Josipovic et al., 2012; Pagnoni, 2012; Taylor et al., 2012). Thus, deliberate mental training provides a promising means of regaining control over deeply ingrained processes.

In addition to overriding undesirable patterns of behavior and cognition, contemplative practices aim to cultivate wholesome mental capacities including attention regulation and meta-awareness (Lutz et al., 2008). Traditional accounts of Buddhist meditation, for example, describe a learning curve wherein sustained attention initially requires a great deal of exertion but later becomes effortless. In line with such phenomenological descriptions, an fMRI study of concentrative meditation reported that highly-experienced practitioners demonstrated improved sustained attention but showed reduced activity in brain areas associated with attention (Brefczynski-Lewis et al., 2007). These results intimate that certain meditative practices may automatize the control of attention and reduce the amount of neural resources required to sustain single-pointed concentration. Furthermore, this improvement in sustained attention likely reflects the de-automatization of habitual fixation on distracting stimuli including task-unrelated thoughts and sensations. Such findings, therefore, highlight the dynamic interplay between automatization and de-automatization in atypical attention and point to the potential of meditative practices to promote other beneficial qualities such as positive affect and compassion (Davidson and McEwen, 2012).

Although meditation is not the same as hypnosis, comparing the modulation of automatic processes across these unique and overlapping practices may help illuminate the neural underpinnings of cognitive control (for a special issue dedicated to juxtaposing hypnosis and meditation, see Lifshitz and Raz, 2012). Similar to our findings involving suggestion, several studies indicate that meditation may lead to reductions in Stroop interference (Alexander et al., 1989; Moore and Malinowski, 2009; Wenk-Sormaz, 2005). Furthermore, recent neuroimaging accounts report that, in response to incongruent Stroop stimuli, experienced meditators displayed reduced fMRI signal in the anterior cingulate cortex (ACC) (Kozasa et al., 2012) and increased error-related negativity (Teper and Inzlicht, 2012) – an early ERP component associated with error detection (for a review, see Hajcak, 2012). These results align with the findings of our studies using posthypnotic suggestion to govern Stroop processing, which likewise demonstrated reduced ACC activity (Raz et al., 2005) and, albeit yet unpublished, altered error-related negativity. Future research would be necessary to elucidate these apparent intersections and further explore the mechanisms supporting the modulation of automaticity as a function of hypnosis and meditation. We hope to report on such efforts before long.

Acknowledgments

This research was supported in part by funding to Amir Raz from the Canada Research Chair program and both Discovery and Discovery Acceleration Supplemental grants from the Natural Sciences and Engineering Research Council of Canada.

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