Atypical Attention

Hypnosis and Conflict Reduction

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This chapter attempts to delineate how altered consciousness (e.g., hypnosis) can illuminate our understanding of attention in common wakefulness. The central tenet of this approach is to keep the experimental paradigm relatively pristine but to gain insight into the attentional process by influencing the subjects' "state" instead (Raz & Shapiro, 2002).

Hypnosis has been used clinically for hundreds of years and is primarily a phenomenon involving attentive receptive concentration (Spiegel & Spiegel, 1987). Despite its long use in clinical settings, hypnosis was only certified by the American Medical Association as a legitimate treatment tool in 1958 and as an effective intervention for pain regulation by a National Institutes of Health panel in 1996. Even so, hypnosis has largely remained an elusive concept for science, partly because it is contaminated by folk beliefs and shrouded in layers of misconception, and largely because the way in which it works has never been adequately explained. Fortunately, with the advent of neuroimaging, this state of affairs is gradually changing.

A recent research program has been able to tap attention in novel ways and shed new light on its neural bases by relating hypnosis, suggestion, conflict resolution, and self-regulation (Raz & Shapiro, 2002). An approach particularly conducive to research is the use of posthypnotic suggestion—a condition following termination of the hypnotic experience, wherein a subject is compliant with a suggestion made during the hypnotic episode but does not remember being told to do so. The posthypnotic suggestion is usually summoned on a prearranged signal and can be effective in highly hypnotizable individuals.

It is possible to classify individuals as either highly hypnotizable (HH) or less hypnotizable (LH) based on their susceptibility to hypnotic suggestion as evidenced in performance on standardized scales. Whereas a number of such scales exist (McConkey & Sheehan, 1982), the Stanford Hypnotic Susceptibility Scale Form C (SHSS:C)—partially due to its robust psychometric characteristics—has frequently been the scale of choice in research (Weitzenhoffer & Hilgard, 1962). Hypnotic procedures generate changes in the way...
at least HH individuals experience themselves and the environment, and these alterations have been shown to affect cognitive processing. Clinicians practicing hypnosis suggest that when one is hypnotized, attentional and perceptual changes may occur that would not have occurred had one been in common awareness. Indeed, hypnotic perceptual alterations in HH are usually accompanied by changes in brain activation (Raz & Shapiro, 2002). Furthermore, HH individuals have been successfully used in assays involving atypical attention (Raz, Fan, Shapiro, & Posner, 2002; Raz, Fossella, McGuinness, Sommer, & Posner, 2003; Raz, Fossella, McGuinness, Sommer, & Posner, 2003; Raz et al., 2003; Raz, Shapiro, Fan, & Posner, 2002a, 2002b, 2002c).

This chapter starts out by reporting on studies showing that HH people can eliminate Stroop interference based on posthypnotic suggestion. When they do so, specific brain changes related to this effect occur. Next, individual differences that might relate to the distinction between high and low hypnotizability are examined. Finally, this chapter discusses hypnotic inductions that might lead to specific deficits and behavioral lesions similar to those found with veridical lesions.

**USING POSTHYPNOTIC SUGGESTION TO REDUCE CONFLICT IN THE BRAIN**

Stroop conflict (Stroop, 1933) is an experimental effect elicited when proficient readers name the ink color of a displayed word. Individuals are usually slower and less accurate, indicating the ink color of an incompatible color word (e.g., responding blue when the word RED is inked in blue) than identifying the ink color of a congruent color name (e.g., responding red when the word RED is inked in red). This difference in performance constitutes the Stroop conflict and is one of the most robust and well-studied phenomena in attentional research (MacLeod, 1991; MacLeod & MacDonald, 2000).

The dominant view in the literature regards reading as a largely automatic process whereby skilled readers cannot withhold activating a word’s underlying meaning despite explicit instructions to attend only to its ink color. Indeed, the standard account maintains that semantic processing of words occurs involuntarily (MacLeod, 1991; Neely, 1991), and that the Stroop task is a model of experimental (cognitive) conflict resolution (Botvinick, Braver, Barch, Carter, & Cohen, 2001).

Some researchers have attempted to explore the Stroop effect under hypnosis (Blum & Graef, 1971; Blum & Wiess, 1986; Dixon, Brunet, & Laurence, 1990a; Dixon & Laurence, 1992; MacLeod & Sheehan, 2003; Nordby, Hugdahl, Jasiukaitis, & Spiegel, 1999; Sheehan, Donovan, & MacLeod, 1988; Spiegel, Cutcomb, Ren, & Pribram, 1985; Sun, 1994; Szechtman, Woody, Bowers, & Nahmias, 1998). However, these assays have largely concentrated on the effect of hypnosis without suggestion and often used nonclassical Stroop paradigms. Historical single-case reports (MacLeod & Sheehan, 2003; Schatzman, 1980), esoteric publications (Sun, 1994), and informal personal communications (T. Wheatley, personal communication, July 5, 2003) proposing hypnotic removal of Stroop conflict have never been rigorously studied.

We examined Stroop interference both in HH and LH subjects with and without a posthypnotic suggestion to see the letters as a meaningless string. As shown in Figure 31.1, we found elimination of Stroop interference in HH but not LH individuals (Raz et al., 2002b). A separate replication of these findings using optical conditions that ensured participants neither looked away nor blurred their vision (i.e., making optical compromise of in-
FIGURE 31.1. (A) Regions of significant fMRI activations on Stroop conflict comparing posthypnotic suggestion with no suggestion in highly suggestible individuals. The Talairach coordinates (x, y, z) for the maximally activated voxel in each of the regions and their Z-value are shown. To relate the fMRI with the ERP data, brain electrical source analyses (BESA) explored the time course of the fMRI generators. (B) The six fixed dipoles placed at locations suggested by the fMRI data. The BESA algorithm provided evidence consistent with independent generators at both the anterior cingulate cortex and cuneus (see Figure 31.1c). (C) Scalp ERPs from a Stroop task showing midfrontal (electrode #6) and midoccipital (electrode #76) activity under both vigilant wakefulness and a specific posthypnotic suggestion rendering words meaningless. These electrodes roughly corresponded with the locations of the anterior and posterior fMRI activations, respectively. All ERPs were relative to a stimulus Stroop word presented at time t = 0. Significant differences (p < .05) between the suggestion-absent and suggestion-present conditions occurred as early as 200 msec following word presentation.
put stimuli unlikely) proposed the involvement of neural top-down control (Raz, Landzberg, et al., 2003).

Multiple neuroimaging studies using variations of conventional Stroop tasks have activated a network of brain areas including the dorsal anterior cingulate cortex (ACC). Requiring participants to respond to one dimension of a stimulus rather than a strong conflicting dimension (Botvinick et al., 2001; Bush, Luu, & Posner, 2000; MacDonald, Cohen, Stenger, & Carter, 2000), these data have resulted in a popular theory of cognitive control proposing that the ACC is part of a network involved in handling conflict between neural areas (Botvinick et al., 2001; Bush et al., 2000). While some researchers view the ACC through the lens of a conflict-monitoring model (Botvinick et al., 2001; Cohen, Botvinick, & Carter, 2000), others construe it as a regulation model engulfing broader processes of consciousness and self-regulation including executive attention and mentation (Bush et al., 2000).

To unravel the brain mechanism by which the posthypnotic suggestion curtailed Stroop conflict (i.e., how suggestion affected visual processing), we studied HH and LH participants both with and without a suggestion not to see the input as words. We complemented the superior spatial resolution of functional magnetic resonance imaging (fMRI) by scalp electrical event-related potentials (ERPs)—affording high temporal resolution—that were acquired separately while the same participants performed similar Stroop tasks. Data from this combined event-related fMRI and ERPs study recently illuminated the mechanism by which the posthypnotic suggestion to view Stroop words as foreign signs operated in HH subjects. The results show that the elimination of the Stroop conflict resulted in an attenuation of fMRI signal at the ACC and extrastriate areas (Raz et al., 2002a, 2002b, 2002c).

These data are consistent with reports that both attention and suggestion can modulate neural activity for visual stimuli (Kosslyn, Thompson, Costantini-Ferrando, Alpert, & Spiegel, 2000; Mack, 2002; Martinez et al., 1999; Rees, Russell, Frith, & Driver, 1999). For example, by creating a situation in which subjects could look directly at a five-letter word without attending to it (i.e., they had to respond to a superimposed stream of pictures shown in different orientations), an fMRI study reported failure to perceive words even for decidedly familiar and meaningful stimuli placed at the center of gaze (Rees et al., 1999). In addition, positron emission tomography (PET) data showed that HH individuals neither perceived color nor activated extrastriate areas related to color after they had been instructed to see a color pattern in gray scale (Kosslyn et al., 2000). Finally, PET assays of pain showed that specific modulatory hypnotic suggestions could affect activation of different brain structures: whereas suggesting a drop in pain unpleasantness (i.e., pacifying conflict) reduced specific activity in ACC (Rainville, Duncan, Price, Carrier, & Bushnell, 1997), suggesting decreased pain intensity produced activity reduction in somatosensory cortex (Hofbauer, Rainville, Duncan, & Bushnell, 2001). These accounts underline the influence attention and suggestion can impart to conflict situations and top-down cognitive control (Posner & Rothbart, 1998; Rainville, 2002; Rainville, Hofbauer, Bushnell, Duncan, & Price, 2002; Raz & Shapiro, 2002).

The higher temporal resolution afforded by scalp ERPs, whose source was localized more anteriorly, illustrated early reduction of brain waves under the experimental suggestion. Comparing the effects of suggestion (absent vs. present) for the incongruent trials in the HH group, electrophysiological activity differed as early as 100 msec following word presentation. These data revealed that in contrast to no suggestion, the N1—an early ERP component believed to be influenced by attention to a channel of information—was absent under suggestion, and posterior activity was not observed before 250 msec. These findings
strongly propose that the absence of conflict was accomplished by changing the way visual input was processed. To relate the fMRI with the ERP data, brain electrical source analyses (BESA) explored the time course of the fMRI generators and provided evidence consistent with independent generators at both the ACC and cuneus.

In addition to data speaking to the reduced conflict-resolution effect, using posthypnotic suggestion, the experimental design demonstrated how it is practically possible to dissociate attention based on input processing from sensory activity based on the input stream. While this outcome seems to leave as a puzzle how visual input got reduced by the posthypnotic suggestion—one possibility is that all input was reduced; another is that it was word specific—the ERP data tend to support the former.

Furthermore, recent ERP data examining the error-related negativity (ERN), an electrophysiological index closely associated with commission of errors in cognitive tasks involving response conflict (Carter et al., 1998; Falkenstein, Hohnsbein, Hoormann, & Blanke, 1991; Gehring & Fencik, 2001), showed that while the posthypnotic suggestion reduced conflict, it did not decrease conflict monitoring (Raz, Fan, & Posner, 2004). Compared to the no-posthypnotic-suggestion condition, ACC activation decreased prior to response under suggestion, but then ACC activation increased upon incorrect responses on incongruent trials regardless of suggestion. Thus, it was possible to eliminate conflict resolution (i.e., early ACC diminution) yet maintain conflict monitoring (i.e., ACC activation following incorrect responses).

Finally, recent behavioral data collected from comparing hypnotic and nonhypnotic suggestions using a similar experimental protocol at the University of Connecticut also showed significant reduction, but not elimination, of Stroop conflict under both hypnotic and nonhypnotic suggestions (Pollard, Raz, & Kirsch, 2003). Interpretation of these data proposed that susceptibility to suggestion, not explicit hypnotic procedures, may have been the critical factor underlying Stroop conflict reduction (Braffman & Kirsch, 1999; Kirsch & Braffman, 2001; Pollard et al., 2003).

**INDIVIDUAL DIFFERENCES IN ATTENTION AND THE GENETICS OF SUGGESTIBILITY**

Using modified Stroop procedures, some researchers have examined HH versus LH subjects outside hypnosis and found reliable differences between the groups (Dixon, Brunet, & Laurence, 1990b; Dixon, Labelle, & Laurence, 1996; Dixon & Laurence, 1992). Stroop interference was significantly larger for the HH subjects compared to the LH subjects. This finding was taken to suggest that outside the hypnotic context, HH subjects processed words more automatically than did LH subjects. However, it may also imply that the baseline efficiency of the executive attention network of HH individuals deviated significantly from the baseline level of LH controls. These findings proposed that HH individuals were perhaps genetically predisposed to elevated levels of executive attention.

Similarly, using non-Stroop executive attention tasks to measure conflict we genotyped participants for a number of genes related to the dopamine system (Fossella et al., 2002) and found that polymorphisms in two genes were significantly related to the efficiency of conflict. These genes were the dopamine D4 receptor gene (DRD4) and monoamine oxidase A (MAOA) gene. The genetic bases of human suggestibility is currently unclear (Bauman & Bul, 1981; Morgan, 1973; Morgan, Hilgard, & Davert, 1970; Rawlings, 1978). Pioneering recent studies seeking to establish relations between phenotype and genotype found an asso-

COMT is a gene that influences performance on prefrontal executive cognition and working-memory tasks (Weinberger et al., 2001). Congruous with both fMRI data identifying signal changes in neuroanatomical loci rich in dopaminergic innervation (e.g., ACC) (Raz et al., 2002a, 2002b, 2002c) and dopaminergic drugs (e.g., propofol) affecting both hypnotic and executive attention (Fiset et al., 1999), valine/methionine heterozygous subjects were more highly suggestive than either valine/valine or methionine/methionine homozygous subjects. The trend of valine/methionine COMT heterozygotes toward higher hypnotizability illuminates data from previous studies examining the role of COMT in executive attention as measured by the Attention Network Test (ANT; Fan, McCandliss, Sommer, Raz, & Posner, 2002) as well as by the Stroop (Sommer, Fossella, Fan, & Posner, in press) and showing enhanced focal attention for carriers of this genotype.

Studies on the ANT found that subjects with the valine/valine genotype showed somewhat more efficient conflict resolution (i.e., less interference) than did subjects with the valine/methionine genotype (Fossella, Posner, Fan, Swanson, & Pfaff, 2002; Fossella et al., 2002). A similar trend was also seen in the Stroop task (Sommer et al., in press). The valine allele of COMT, which confers relatively higher levels of enzyme activity and thus lower relative amounts of extrasynaptic dopamine, has been examined in the context of neuroimaging studies where it correlated with lower activity of the dorsolateral prefrontal cortex (Egan et al., 2001). These data are helpful in the quest to identify persons who are likely to be susceptible to suggestion and classify individual attentional profiles as well as subtypes of suggestibility. Interpretation of these results may imply that the baseline efficiency of the executive attention network of HH individuals differs significantly from the baseline level of their LH counterparts. In this regard, the COMT findings recommend a genetic approach to hypnotizability whereby a genotype may suggest a “biological propensity” that predisposes to an attentional phenotype (e.g., hypnotizability).

**MANIPULATING THE SUBJECT:**
**VIRTUAL LESIONS AND BEHAVIORAL LESIONS**

In the tradition of neurological science, considerable understanding of the healthy human brain typically relied on insights from pathology and trauma. Studying the deficits seen in lesion models both of nonhuman primates and human patients with well-defined brain injuries has been an influential source of pertinent information. Whereas researchers in social psychology may “push” normal individuals toward the pathological spectrum in their efforts to illuminate behavior (Wegner, 2002), cognitive neuroscientists have largely remained within the traditional approach (i.e., studying patients with specific brain lesions to illuminate the nonpathological brain). The investigation of healthy individuals driven toward the “pathological” domain is evident in both the recent contribution of social psychologists to cognitive science (Wegner, 2003) and the popularity of “virtual lesions” induced by transcranial magnetic stimulation (TMS).

Using both hypnotic and posthypnotic suggestions, we have obtained exploratory “behavioral lesion” data. Our assays examine the behavioral consequences of specific suggestions, agreeable with the behavioral manifestations of patients with lesions (e.g., hemi-
inattention neglect), on healthy HH individuals. As a case in point, recent pilot data show that three neglect-naive HH individuals instructed to “pay more attention to the right side of space” and “feel more drowsy and sleepy” the left side of their bodies have become yielded behavioral responses comparable to those seen in veridical neglect patients on neuropsychological tests (e.g., line bisection, figure drawing, and extinction).

These findings are congruous with other hypnotic accounts. For example, within-vision hypnotic suggestions have been demonstrated to induce scotomas and tunnel vision (e.g., Blum, 1975; Leibowitz, Post, Rodemer, Wadlington, & Lundy, 1980), achromatopsia (e.g., Kosslyn et al., 2000), alexia (Raz et al., 2002b), and agnosia (e.g., Blum & Wiess, 1986). Such phenomena are not limited to vision (e.g., Szechtman et al., 1998).

Thus, behavioral lesions induced by hypnotic or posthypnotic suggestion can similarly be used as a way to supplement data from permanent lesions (e.g., strokes) and temporary lesions (e.g., TMS). Hypnosis is especially suited for targeting the modulatory role of attention and for exploring such effects on sensory and cognitive processes because the risk of harm from hypnosis is low and illuminating attention with hypnosis commonly involves global and systemic effects.

CONCLUSION

Behavioral interventions and their neurobiological impact can be both highly focused and functionally specific (Raz & Michels, 2004). There are converging data showing that at least for HH individuals, posthypnotic suggestion can influence both behavior and focal neural activations via a behavioral intervention. Reducing conflict using posthypnotic suggestion has been shown to affect both the input attributes—proposing a global filtering of visual stimuli—and downstream activity in the ACC, an important part of neural systems related to executive attention and self-regulation.

Atypical assays of attention, whereby normal subjects are transiently transformed into neuropsychological patients, may illuminate neurocognitive issues. Hypnosis presents a behavioral TMS-like variant, and researchers would do well to consider “behavioral lesions” as a promising vehicle to probe attention in novel ways.

REFERENCES


