Chapter 19

From dynamic to behavioural lesions: The relative merits and caveats of elucidating psychoanalysis with brain imaging

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Abstract

Contemporary studies in the cognitive neuroscience of attention and suggestion shed new light on psychoanalytic concepts of yore. Recent findings from neuroimaging studies, for example, seem to revive the notion of dynamic lesions—those focal brain changes undetectable by anatomical scrutiny. Whereas nineteenth-century psychiatry attempted to apply the dynamic lesion model to disorders such as hysteria, contemporary biological psychiatry—with technologies such as brain imaging and reversible brain lesion—provides converging findings reminiscent of early accounts by the old masters. In particular, suggestion has been shown to modulate specific neural activity in the human brain. Here we show that 'behavioural lesions'—the influence words exert on focal brain activity—may constitute the twenty-first-century appellation of 'dynamic lesions'. While recent research results involving suggestion seem to partially support Freudian notions as well as modern-day psychoanalytic ideas, correlating psychoanalysis with its brain substrates remains difficult. We elucidate the incipient role of cognitive neuroscience, including the relative merits and inherent limitations of imaging of the living human brain, in explaining psychoanalytical concepts.

Keywords: suggestion; brain imaging; hypnosis; cognitive neuroscience; psychoanalysis; fMRI.

Introduction

Alongside the established science of attention, the emerging science of suggestion is gradually reframing core psychoanalytic ideas. Suggestion and attention are pivotal themes in cognitive science (Raz and Buhle, 2006). Together, they increasingly lend support to the link between the brain and behaviour, and they bind psychology to the techniques of neuroscience (Posner and Rothbart, 2007a). More specifically, experimental findings show that suggestion and attention influence cognition, affect, thought, and action (Posner and Rothbart, 2005, 2007b), all of which originate at the brain level and affect behaviour. Furthermore, studies involving genetics as well as imaging

Box 19.1 Term definitions

Suggestion: A psychological influence that affects individuals according to their subjective experiences or beliefs. Highly suggestible individuals can more readily enter a state of hypnosis.

Hypnosis: A state of extreme relaxation and heightened focus in which individuals readily respond to suggestion. While individuals under the influence of hypnosis feel as if an outside force is causing their behaviour, they are in complete control of their own behaviours and can exit a hypnotic state at any time.

Dynamic lesions: A term coined by Jean-Martin Charcot to describe what he thought occurred in the brains of hysteria patients. Charcot proposed that suggestion produced anatomical brain changes (dynamic lesions) that in turn caused symptoms such as hysterical blindness and paralysis. Charcot believed dynamic lesions existed even though he could never find them on autopsy.

Behavioural lesions: Our own term to describe what Freud posited, and later, brain imaging confirmed, occurs in the brains of individuals under the influence of suggestion; that is, fleeting, reversible brain changes that influence behaviour. These 'lesions' are reminiscent of Charcot's notion of dynamic lesions except that they are neither permanent nor anatomical in nature.

of the living human brain begin to unravel both the neural underpinnings of suggestion and its underlying mechanisms (Posner et al., 2007; Raz, 2008a). These reports permit a deeper look into the inner workings of suggestion and findings from such studies seem to at least partially resonate with hypotheses from early analytic thinkers. While many classic psychoanalytic concepts scarcely lend themselves to rigorous experimental scrutiny, brain mechanisms underlying the connection between mental activity and associated response are coming to light.

Recent findings may elucidate early psychoanalytic ideas regarding the power of suggestion. The term 'suggestion' has survived the leap from Freudian to modern-day psychology, but its conceptual label has been redefined. The French neurologist Jean-Martin Charcot coined the term 'dynamic lesions'—anatomically unobservable neurophysiological alterations that produce a marked change in behaviour—to explain the mechanism at work in hysteria patients (Charcot, 1889). Thereafter, Freud theorized that certain behaviours do not derive from tangible insults to the brain, but rather result from real bodily changes that take place in response to language that temporarily affects brain activity (Freud, 1893). Most scholars agree that by 'language', Freud likely referred to abstractions that go beyond mere words (Makari, 2008). In line with Freudian reasoning, we submit that the central formulation of suggestion—a psychological influence that affects individuals according to their subjective beliefs and experiences—derives its power from 'behavioural lesions' of the brain that alter function without changing structure.

Via brain imaging, the connection between dynamic and behavioural lesions highlights a few basic psychoanalytic concepts. For example, the brain changes that occur in response to suggestion elucidate certain unconscious processes and defence mechanisms inherent to psychoanalysis. As a case in point, in his work with hysteria patients, Freud made the link between repression of thoughts and feelings into the unconscious and the way in which people handle stimuli under hypnosis (Kline, 1953). The power of words to alter brain function, as recent studies uncover, demonstrates that responses to suggestions are involuntary—neurological changes occur to form behavioural lesions while participants are largely unaware of these processes.

Examining psychoanalysis through the lens of cognitive neuroscience, this chapter focuses on the modern findings that rekindle the old flame of dynamic lesions. We demonstrate how recent research findings from studies of suggestion are congruent with at least some psychoanalytic concepts. Although potentially appealing, the conceptual reduction of psychoanalysis to specific brain mechanisms seems unlikely. We outline the shortcomings and relative virtues of such a reductionist account and submit that neuroimaging only provides limited support for psychoanalysis. Finally, we discuss findings from the field of neuropsychoanalysis to illustrate that the modern conceptualization of behavioural lesions is similar to Charcot's and especially Freud's appellation of suggestion.

From dynamic to behavioural lesions

The introduction of dynamic lesions was helpful in explaining how psychological stressors may propel organic brain changes (Chertok, 1977). Observing hysteria, Charcot postulated that temporary neural changes correspond with patient symptomatology. According to Charcot, for example, a material change in a portion of the right hemisphere was responsible for hysteric paralysis of the left arm (Koehler, 2003). Although unable to visibly locate a focal brain abnormality to account for his patients' symptoms (Goetz and Bonduelle, 1995), Charcot considered dynamic or 'functional' lesions to be the underlying cause. Thus, the emerging dynamic lesion model linked organic disorders with unexplainable somatic symptoms—or what we now designate as 'psychogenic disorders'.

Reminiscent of dynamic lesions, the recent technology of transcranial magnetic stimulation (TMS) produces transient changes in brain function. TMS delivers a short burst of a powerful magnetic field to a specific brain area, thus inducing a temporary brain 'lesion' which is reversible in nature and leaves no anatomical traces (Bohning, et al., 1998). Brain researchers uncover more complex lesion-like behaviour using variations of this methodology including repetitive TMS, which induces longer-lasting yet temporary changes (George, 2003). Despite differences, intriguing overlaps bind TMS-induced dysfunction to Charcot's age-old concept of dynamic lesions.

Increasingly ubiquitous, functional magnetic resonance imaging (fMRI) is a non-invasive brain measurement technology, opening a window into the neurological underpinnings of behaviour. fMRI can unravel the behavioural lesions that specific suggestions can invoke by examining the influence of words on the workings of the mind (Raz and Shapiro, 2002; Shapiro, 2004). For example, armed with hypnotic suggestion as an experimental intervention, multiple imaging studies have shown how specific suggestions correlate with focal brain changes (Raz, 2004; Raz and Buhle, 2006; Raz et al., 2005b). Suggestion has been shown to influence neural processing in the domains of colour vision (Kosslyn et al., 2000), audition (Szechtman et al., 1998), pain (Kong et al., 2007; Rainville et al., 1999), and word-reading (Raz et al., 2002, 2005a, 2007b). Box 19.2 sketches out the top-down effect of words on brain function. Findings from these 'behavioural-lesion studies' outline the neural correlates underlying the way experimental suggestions can dramatically change behaviour. fMRI, therefore, may support the link between dynamic and TMS-induced lesions.

Early ideas surrounding dynamic lesions seem relevant in our technology-laden era. While TMS can emulate dynamic lesions, fMRI affords a look into the behaving brain. Despite substantial technological challenges, concurrent TMS–fMRI measurements are beginning to occur (Denslow et al., 2005). When properly yoked, these disparate techniques seem to complement one another to elucidate the spectrum of dynamic-behavioural lesions.

Suggestion: Freud and beyond

From parlour magic and hysteria-inspired psychiatry all the way to contemporary brain research, suggestion has made its way into empirical science (Harrington, 2008; McHugh, 2006). Freud was responsible for much of the conceptualization of this transition, although his original ideas were

Box 19.2 Suggestion reduces Stroop conflict

In the classic Stroop task, participants identify the ink colour of printed letters. Individuals are usually slower and less accurate indicating the ink colour of an incompatible colour word (e.g. responding 'blue' when the word 'RED' is displayed in blue ink) than identifying the ink colour of a congruent colour 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). The dominant view 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 colour (MacLeod and MacDonald, 2000).

Findings from participants who performed a classic Stroop task both with and without a post-hypnotic suggestion to obviate the Stroop conflict challenge the automaticity of the Stroop effect. The suggestion, that the stimuli (that is, English Stroop words) would be meaningless scribbles written in an unfamiliar foreign language, either removed or reduced Stroop interference and facilitation in highly hypnotizable participants (MacLeod and Sheehan, 2003; Raz, 2004, 2006; Raz, et al., 2002, 2003, 2007b). Reports on the neural correlates of this phenomenon unravel a complex and compelling story (Raz et al., 2005a). If suggestion can override what most cognitive scientists consider an automatic process such as reading, we may need to revisit the notion of automaticity. In line with Charcotian ideas, the top-down influence of suggestion could have important therapeutic potential in automation reversal of other ingrained behaviours in the context of certain psychopathologies and in elucidating the neural substrates of placebo responses. For example, our pilot data from children diagnosed with Tourette's syndrome show that hypnotic suggestion can transiently ameliorate tic symptoms (Raz et al., 2007c). The idea of testing an individual while changing their attentional efficiency with suggestion, rather than altering the experimental task, is in line with recent reports about the effects of attentional training and expert meditators (Kerr et al., 2008; Lutz et al., 2008). Highly hypnotizable individuals—that is, the vast majority of children and about 15% of adults—could well be candidates for investigation in this new field (Raz and Buhle, 2006).

neither accepted by his contemporaries nor condoned by modern-day behavioural scientists (e.g. see individual peer commentaries by Crews, Kihlstrom, McNally, and Wegner in (Erdelyi, 2006)). Nevertheless, Freud's notion that suggestion and hypnosis comprise psychological states, expectations, attention, and role playing, is the basic focus of hypnosis research today (Bachner-Melman and Lichtenberg, 2001). Box 19.3 sketches Freud's operationalization of the concept of suggestion. See also Oakley (Chapter 20), this volume, for a comprehensive overview of Freud's dabble in hypnosis.

Freud's initiatives had been taken up by psychoanalytically trained psychiatrists, who demonstrated that suggestion can elicit real changes. One study, for example, examined the effects of hypnotic suggestion on urine output in patients who had been deprived of fluids for about 15 hours (Hulet et al., 1963). After suggesting to patients that they had drunk six glasses of water, their urine flow increased as much as fivefold relative to a pre-hypnotic baseline condition in which their bladders had been emptied. Findings from comparable studies using neuroimaging illustrate significant signal changes in brain areas associated with sensation and perception (Raz et al., 2005a). For example, under the influence of post-hypnotic suggestion, highly suggestible individuals—who are otherwise proficient readers—become incapable of reading or processing word stimuli at the

Box 19.3 Suggestion and Freud (Figure 19.1)

Following Ribot's model, Charcot employed associational psychology alongside hereditary explanations to conclude that hypnotic suggestions permit ideas to enter the mind. At that time, intellectuals such as William Carpenter in England and William James in America speculated that humans are actually automata reigned by unconscious physiology. Instead of focusing on physiology, however, Charcot's novel approach relied on psychology. His growing psychological theory was compelling: if one idea could cause paralysis then another idea may cure it. Together with Freud, physicians from around Europe flocked to Paris to witness how Charcot's dazzling feats of hypnosis and suggestion resulted in dramatic behaviours. These doctors were eager to learn the scientific method of the *psychologie nouvelle*—a method that would disintegrate soon after.

Leaving Vienna and fleeing mounting criticisms of his advocacy of cocaine, Freud arrived in Paris to learn from Charcot that the days of great discovery in pathological anatomy were over. Charcot was adamant to go beyond anatomical lesions. Although some of Freud's mentors (e.g. Brentano) argued that the science of the mind was too undeveloped to marry physiology with psychology, Charcot and his impressive cadre (e.g. Babinski and Gilles de la Tourette) wowed Freud. Returning to sceptical Vienna, Freud was certain that the altered consciousness phenomena of hypnosis were genuine. He was becoming a prominent Viennese representative of French ideas about hysteria, hypnosis, psychology, and psychopathology, even as incipient cracks began to foreshadow Charcot's demise.

In 1886, Hippolyte Bernheim of Nancy published his own landmark study, *On Suggestion and Its Therapeutic Applications*, in which he challenged two major tenets of the Salpêtrière. Bernheim claimed that hypnosis was incongruent with psychopathology and that trances were easy to elicit in the majority of both women and men. Furthermore, Bernheim claimed that hypnosis was not even necessary for suggestions to take effect (cf. Raz et al., 2006). Trying to pre-empt a demoralizing blow, Freud decided to translate Bernheim's book into German. By 1888, readers of the German text encountered an aggressive translator who contended the author. The debates between the Nancy and Salpêtrière schools generated considerable research and findings that largely countered many of Charcot's dogmas. Consequently, post-1888 Freud began to distance himself from his colleagues in Paris and sidestepped defending Charcot's positions, mentioning that it was incumbent upon advocates of the Salpêtrière to prove their theories.

Freud's rebuttal and critiques of Bernheim and Charcot mark the outline of what would become distinctly Freudian ground. By 1892, Freud began to distinguish himself in a crowded field of psychopathologists and suggestive therapists. Through a deep engagement with French medicine, he proposed a model that had the potential to redefine the study of psychopathology. In Paris, however, his ideas won him lifelong enemies, making France hostile to Freudians over the next decades. Sigmund Freud and Pierre Janet, for example, became harsh rivals: while Janet discounted Freud's work as derivative and disparaged its critical innovations as flawed, Freud dismissed Janet for his insistence on an inherited feeble-mindedness in hysterics. Leaving behind French psychopathology, Freud tried to secure his new discoveries by finding a place for them in a scientifically tenable model of the mind. Suggestion was central to Freud's theme.

Box 19.3 Suggestion and Freud (continued)

Freud's view of suggestion as 'a conscious idea, which has been introduced into the brain of the hypnotized person by an external influence and has been accepted by him as though it had arisen spontaneously' (1888, p. 77) is congruent with today's understanding of the phenomenon (i.e. that under the influence of suggestion, people may undergo temporary physical changes that are solely the product of their own mental states (Raz and Shapiro, 2002)). Freud noticed that his patients' symptoms were incompatible with symptoms of organic lesions (e.g. patients with hysterical paralyses did not show the degree of muscle atrophy present in those with biological paralyses (Koehler, 2003)), and he reasoned that no fundamental brain damage had occurred. His resulting theory that 'slight and transitory' (Freud, 1893, p. 168) dynamic lesions in certain brain regions affect respective body parts is similar to the short-lived behavioural lesions we propose today (Raz, 2008a).

semantic, phonological, or orthographic levels (Raz et al., 2002, 2003, 2005a, 2007b). These indirect neurological indices form the backdrop for the resurfacing of Freud's 'mysterious leap from mind to body' (Shapiro, 2004, p. 339). Indeed, selective findings from empirical neuroscience have been presumed to support, at least in part, psychoanalytical ideas.

Modern formulations of suggestion overlap with the increasing cachet of psychosocial parameters in medicine, including demand characteristics (Laurence et al., 2008), expectations (Benham et al., 2006), and placebos (Kirsch, 1985; Lynn et al., 2008). These effects have to do with medical changes arising from knowledge that therapy is occurring, rather than from actual effects of a drug or treatment (Benedetti et al., 2003). Previously vilified as products of 'mere suggestion', such psychosocial parameters are slowly gaining a respectable place in modern medicine (Raz and Guindi, 2008). Norman Cousins, for example, made his way from a serious collagen illness back to health by moving himself from a hospital to a hotel, ingesting large doses of vitamin C and using laughter as medicine (Cousins, 1976). Whether he was the product of auto-suggestion or self-administered placebos, the mechanisms at work seem similar. Recent experimental findings show that context—including doctors' words, attitudes, and behaviours—may affect pathological conditions through the modulation of specific neurochemical mechanisms (Benedetti, 2002). The contribution of psychosocial factors to medical change, therefore, illuminates the modern-day conceptualization of suggestion.

Revisiting the unconscious

Following in Charcot's footsteps, Freud made the connection between unconscious influences and symptomatic behaviour. Bearing witness to Charcot's use of suggestion to induce hysteria in otherwise healthy patients, Freud came to accept psychical problems as symptoms created by the unconscious mind of the patient (Silverstein and Silverstein, 1990). In addition, Freud noted similarities between certain defence mechanisms used by psychiatric patients and responses carried out under the influence of suggestion (Kline, 1953). In observing the symptom relief his patients experienced when they explored underlying causes of their distress, Freud likened the process of hysteria to the hypnotic phenomenon of blocking peripheral thoughts from awareness. Freud's psychoanalytic conceptualization of hysterical symptoms carries forward to the phenomena acting on psychopathological patients today.

Brain scans of psychogenic patients show neural activity similar to that of highly suggestible individuals. In one reported account of a woman with hysterical left-sided paralysis, brain scans showed no activity in the right primary motor cortex upon instruction to move her left leg; instead, activity occurred in two areas of the brain typically involved in inhibiting the prefrontal effects of willing the leg to move (Marshall et al., 1997). A later imaging study reported similar results with hypnosis: upon suggestion of paralysis, highly hypnotizable people showed inability to move their limbs on command. Furthermore, positron emission tomography (PET) scans showed activation of the same brain regions that were indicated in the above case study. Taken together, findings from these studies suggest that conversion hysteria shares the same brain-body mechanisms as hypnosis (Halligan et al., 2000). (Refer to Oakley (Chapter 20), this volume, for a more comprehensive overview of these last two studies.) While hysteria is an archaic term, the

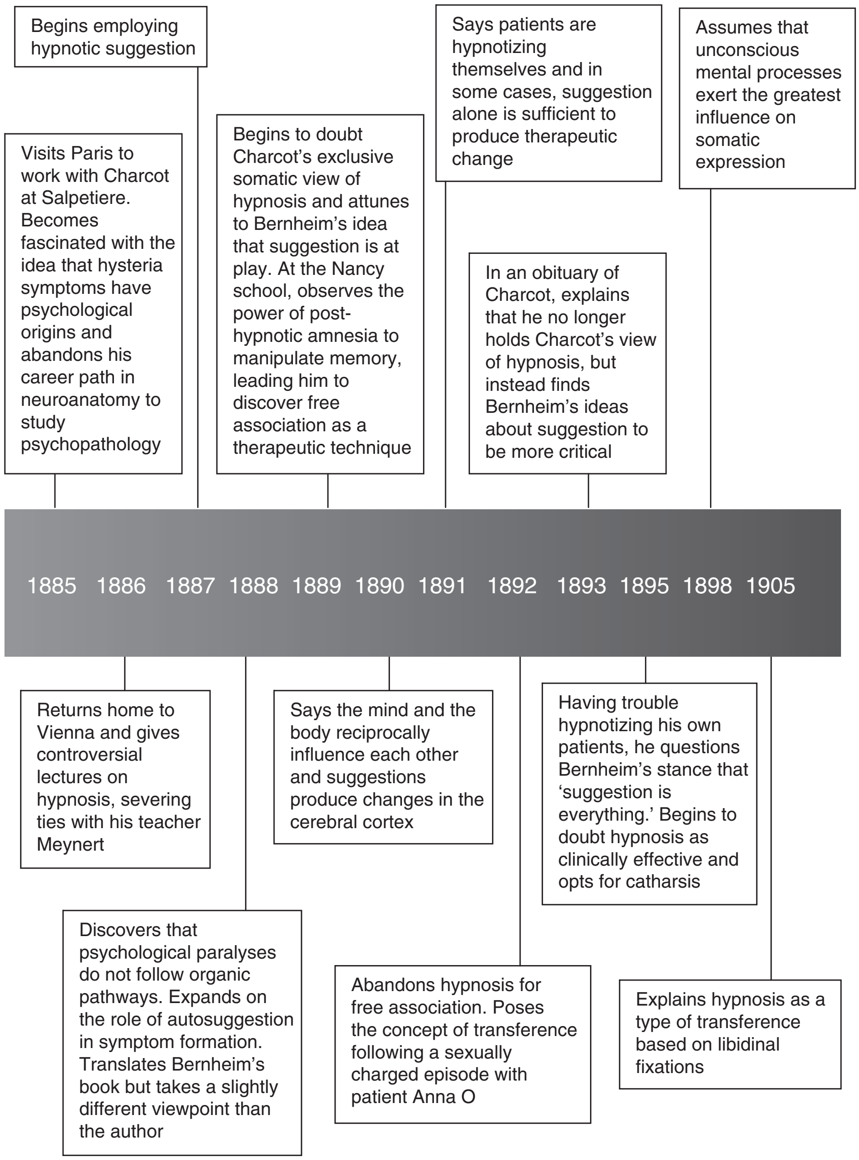

Fig. 19.1 A timeline of Freud's deepening appreciation for suggestion.

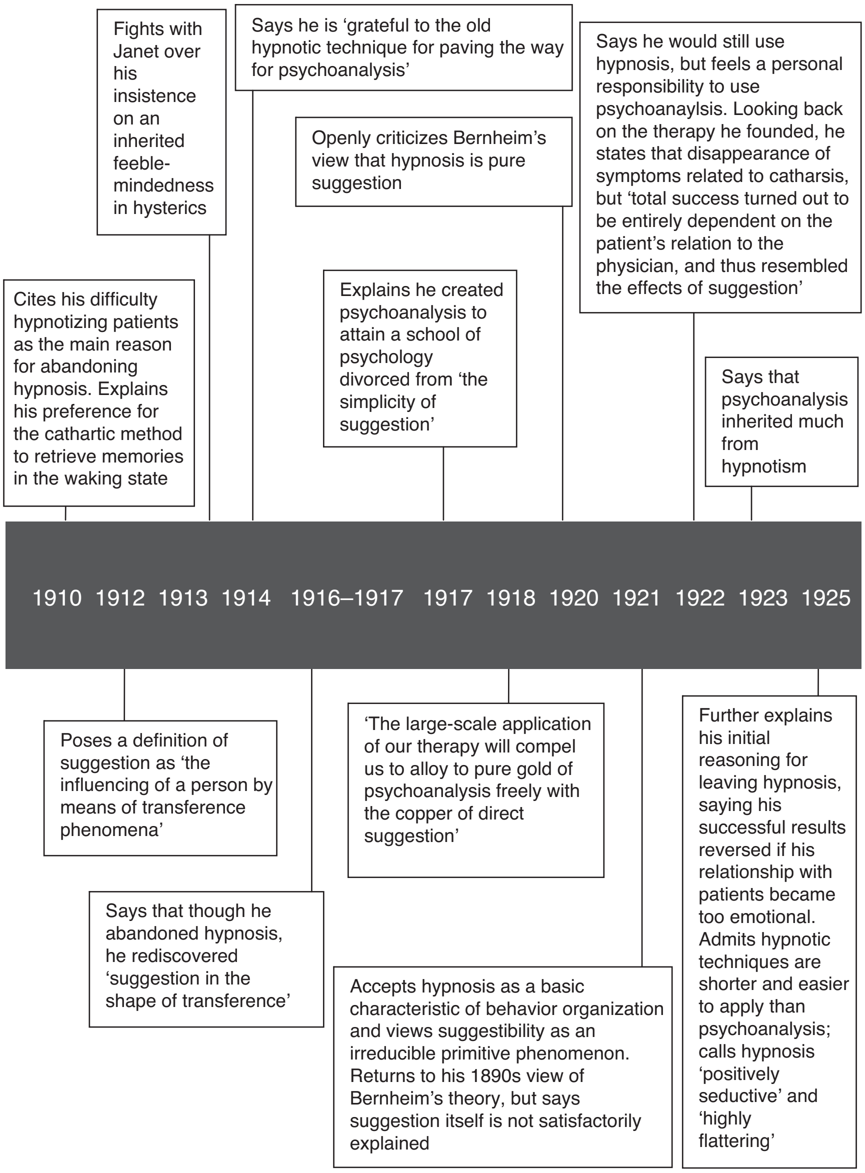

Fig. 19.1 (Continued).

concept that people may unconsciously influence their own neurophysiological processes plays out with today's understanding of the pathway of suggestion.

Beyond eliciting symptoms, suggestion may alter unconscious thought processes. Studies have shown that context and expectation can alter cognition. For example, one study with the Implicit Associations Test (IAT; Greenwald et al., 1998)—a task presumed to measure people's implicit attitudes about different groups of objects—showed that manipulation of context could rapidly change the outcome of people's 'unconscious' beliefs. Specifically, when subjects read about an uncommon scenario in which flowers were bad and insects were good for the environment, subjects had faster reaction times for pairing flowers with negative words than insects with negative words, indicating that the suggestion produced immediate effects. When a matched sample of subjects received only a simple instruction to view insects as good and flowers as bad, their natural tendency to see flowers as good did not change, further illustrating that suggestion can likely influence these associations. The idea that people may unknowingly alter their beliefs following suggestion revives Freud's notion that unconscious processes guide mental and physical responses.

Joining psychoanalysis with (cognitive) neuroscience

Reconciling psychoanalytic and neuroscientific perspectives is an honourable, albeit difficult mission, especially when sticking with the traditional outlooks of each field. In the beginning, Freud sought a description of behavioural and mental functioning that was consonant with contemporary neuroscience (Freud, 1985/1950). Although neuroscience is the generic term, the common allusion is to the subfield of cognitive neuroscience—the study of how the brain enables the mind. Even if incongruent with Freud's original aspirations, some of today's psychoanalysts posit that melding (cognitive) neuroscience with psychoanalysis is a potential oxymoron since each field represents a radically different standpoint (e.g. Makari, 2008). This stance encompasses the view of neuroscience that talks about biological disease entities while avoiding the 'messiness' of psychology, meaning, or culture (Kirsch, 1985, 2008; Raz and Guindi, 2008). The viewpoint the neuroscience is 'neat', while psychology is 'messy' is one side of an historical neurophilosophical argument; still, the professional tendency of certain fields is to focus on how organic brain function influences thoughts and behaviour, rather than on how mental activity affects the brain. Psychiatry, for example, a field mostly interested in the social sciences for much of the twentieth century, has mainly submitted to a biological paradigm for the past 25 years (Luhrmann, 2000; Shorter, 1998). Psychoanalysis, on the other hand, has traditionally put forth many ideas that do not allow for empirical support through neuroimaging, or other neuroscientific methods. There are no brain regions, for example, that correspond to the specific activities of the id, ego, or superego, unless these are put forward as specific, falsifiable hypotheses (e.g. certain ego functions can be conceived as specific executive functions of the prefrontal lobes (see Anderson and Green, 2001; Fotopoulou, 2010; Kaplan-Solms and Solms, 2000; Ramachandran, 1994).

The language and conceptualization of neuroscience have customarily been vastly different from those of psychoanalysis. Even for fundamental terms of art that seemingly look and sound the same, neuroscientists and psychoanalysts are often worlds apart (Westen and Gabbard, 2002). According to Charles Brenner, for example, psychoanalysis applies to the study of the mind in conflict. Appellations such as 'conflict' and 'conflict resolution', however, signify radically different meanings in psychoanalysis and in neurocognition. Freud anchored his notion of conflict in instinct theory while neuroscientists typically eschew drive and conflict to focus on perception or memory (e.g. variants of the Stroop effect (MacLeod and MacDonald, 2000); although see the section 'Drive and motivation' for some exceptions). Cognitive neuroscientists rarely construe conflict as the fundamental Freudian rivalry between sex and aggression. Likewise, psychoanalysts seldom view conflict through the lens of Stroop-like tasks (Raz and Buhle, 2006). Traditionally speaking, cognitive neuroscience has a rather circumscribed discourse regarding conscious mental operations, self-awareness, and subliminal information processing, whereas psychoanalysis draws on the immense world of the unconscious, emotion, and motivation.

The gap between the semantics of each field is narrowing as psychoanalysis and neuroscience each modify their languages and broaden what they study, but it still remains unclear how well new terminology illuminates psychoanalysis at work in the brain. Neuroscience, for example, has more recently talked about 'motivation'; but while psychoanalysis looks at motivation of behaviour stemming from unconscious wishes and drives (and more recently from affect and attachment; see Oppenheim (Chapter 16), this volume), neuroscientists usually examine biological drives like hunger and thirst. Studies of the seat of motivation in the brain thus far have shown that no brain area lines up neatly with any type of motivation and brain lesions rarely eliminate a motivation completely (Berridge, 2004). Neuroscientific trends have also moved towards exploring unconscious brain processes, such as the study of decision making (Soon et al., 2008) and emotional processing (Tamietto and de Gelder, 2010) that are out of awareness. Such studies have added to other established methods, such as subliminal priming paradigms (see Bazan chapter) and implicit tasks (e.g. the IAT) in showing that unconscious processes exist. However, questions remain as to how unconscious emotional processing affects behaviour (Tamietto and de Gelder, 2010), how such a brain–body process occurs, and whether or not these studies of the cognitive unconscious can be compared with the dynamic unconscious at the core of psychoanalysis (see Oppenheim (Chapter 16), Rees (Chapter 17), and Solms and Zellner (Chapter 12), this volume). While neuroscientific studies make bold attempts to meld psychoanalysis and neuroscience, many psychoanalytic concepts, as they stand, remain untapped by neuroimaging. Perhaps in the future, extensions and revisions to psychoanalytic theory will allow for more testable predictions as additional research increasingly draws on new methodologies, including behavioural lesions, TMS, and fMRI.

Proponents within each field have differing views on how well psychoanalysis can map onto neuroscience, even with changing definitions (see round table discussion—*Psychoanalysis and Neuroscience: Ten Years Later*, 2010, Philoctetes Centre, NY). Psychoanalysis' original concern with the 'ego' has gradually morphed into an interest in the much more psychological notion of the 'self' (Hartmann, 1956). This shift is critical because the self has become a central concept, arguably as fundamental as ego had been in the earlier period. Yet some believe that while the gap between psychological science and neuroscience (i.e. between ego and the brain) may be getting smaller, the gap between old and new psychoanalytic terminology (i.e. between the ego and the self) seems as wide as ever (e.g. Michels, 2008). On the other hand, while it 'would be fool-hearted to try and reduce [psychoanalytic questions] to neuroscientific pigeonholes,' breaking psychoanalysis down into very specific component parts might be more amenable to neuroscience than trying to answer complex questions (Solms, *Psychoanalysis and Neuroscience: Ten Years Later*, 2010, Philoctetes Centre, NY). Whereas psychological constructs, such as attention, strengthen the connection between brain and behaviour and submit psychology to the techniques of neuroscience (Raz and Buhle, 2006), psychoanalytical concepts, such as the ego, remain largely unbridgeable in mainstream neuroscience.

Psychoanalysis and the perils of neuroimaging

Hardly any advance in neuroscience has garnered as much public interest as imaging of the living human brain. To see the human brain in action seems to mesmerize the masses, including many a psychoanalyst. For example, because transference might be operationalized experimentally (Berk and Andersen, 2000), psychiatrists have proposed an fMRI study to capture transference phenomena (Gerber and Peterson, 2006). Before examining results from any imaging excursion into one of the cornerstones of the psychoanalytic processes, however, the psychoanalytic community may want to ruminate about what will likely transpire.

Technologies such as fMRI entice researchers to submit higher brain functions, including morality (Greene et al., 2004), to scientific scrutiny. Viewing the active human brain via images harboured by such efforts, however, may enthral more than explain (McCabe and Castel, 2008). This type of 'neurorealism' leads individuals to believe that images of brain activity make a behavioural observation more veridical (Racine et al., 2005). Consequently, media coverage frequently oversimplifies research findings and marginalizes caveats (Racine et al., 2006). In the heat of the last presidential race in the United States, for example, a controversial *New York Times* op-ed column made predictions about the outcome of the upcoming election based on fMRI data from undecided voters who had viewed photographs and videos of the major candidates that were running (Iacoboni et al., 2007). As a subsequent editorial in *Nature* pointed out, however, studies that contrive elaborate stories about the results of brain scans are irresponsible, since conducting well-designed experiments is considerably more difficult than obtaining comely brain renderings (2007). Indeed, interesting concoctions of neuroscience have already found their way to print (Brizendine, 2006; Westen, 2007), but as the use of fMRI becomes more ubiquitous, consumers of neuroimaging—neuroscientific and psychoanalytic researchers included—may benefit from a measure of rigor.

Rendering psychoanalytic concepts amenable to neuroscience research calls for a keen appreciation of the limitations of neuroimaging. One of the core shortcomings of a naïve fMRI approach hinges on reverse inferences—inferring a specific mental state from the activation of a particular brain region (Aron et al., 2007). For example, anxiety involves fMRI signal changes in the amygdala, but so do many other things, including intense smells and sexually explicit images. Thus, to surmise that amygdala activity is a strong prognostic of negative emotion may be misleading. Despite this knowledge, reverse inferences are particularly common in newer fields such as social cognitive neuroscience and neuropsychoanalysis, in which researchers are still trying to identify the cognitive processes underlying the behaviours they study. One study, for example, used fMRI to investigate the neural underpinnings of individuals who were mulling over moral dilemmas (Greene et al., 2001). Brain areas with fMRI signal changes included regions that had been linked to 'emotional' and 'rational' cognitive processes in previous studies, so researchers concluded that these processes are active in different types of moral judgements. It so happens, however, that at least some of the emotional brain regions in the morality study have also been associated with memory and with language, although these alternative explanations typically escape mention (Miller, 2008). Although reverse inferences may still be useful in specific situations, cumulative analyses over the past few years have resulted in marked disillusionment regarding many of the reverse inferences presented in the literature. Thus, past support for reverse inferences has taken a turn against it (Poldrack, 2006).

fMRI has transformed neuroscience in fewer than two decades, but many studies shed little light on the neural mechanisms of human cognition, affect, thought, and action. Even when researchers attempt to confront the limitations of fMRI by trying to match human fMRI data with analogous brain recordings in non-human primates, they are hard-pressed to apply this study to many types of human cognition, including psychoanalysis. Comely fMRI-generated images may seduce the general public, but even neuroscientists seem to fall for them and overlook the limitations of neuroimaging. Because these images can only capture a narrow sliver of the human experience and can only represent large-scale activities, fMRI is an indirect, crude tool for investigating how neuronal ensembles 'compute' cognition and behaviour. fMRI can be helpful in guiding where something is happening in the brain, but it is considerably more difficult to use fMRI to elucidate mechanisms.

The promise of neuroimaging

A very different approach to overcoming some of fMRI's constraints may begin to bridge the gap between psychoanalysis and neuroscience. In a standard fMRI study, neuroscientists average together the activation from neighbouring units of imaging (i.e. voxels), but it is unlikely that neurons from different voxels all behave the same way. With new analysis tools borrowed from machine learning research, it is possible to take a finer grained look at brain activity that considers patterns of activation across many individual voxels without averaging. These methods shift the focus from trying to identify the specific brain regions activated during a particular task to trying to identify how the brain processes relevant information.

This new statistical approach can reveal information processing in the brain that would be overlooked by more conventional analyses (Raizada, 2008). In the first demonstration of this new method, investigators were able to identify statistically distinct brain activity patterns that different types of objects (e.g. faces, cats, scissors) elicited (Haxby et al., 2001). Rather than looking at whether a specific brain region is active, researchers are beginning to focus on whether the activity in many different voxels can predict what people are experiencing. In other words, instead of inferring that a spider induces anxiety, researchers could collect patterns of brain activity evoked by known anxiety inducers (e.g. photos of hypodermic needles) and see whether the spider pattern forms a statistical match. Even with these more promising tools, fMRI can largely reveal correlations between cognitive processes and activity in the brain, but such classifiers help rescue fMRI research from the logical perils of reverse inference.

While it may be difficult to find empirical ways to elucidate psychoanalytic concepts, neuroimaging can offer a glimpse into the brain changes that occur during crucial patient–therapist interactions. Budding labours have taken a preliminary look at these scantily explored aspects. One line of such effort, for example, took the form of hyperscanning paradigms (Babiloni et al., 2006, 2007a,b; Montague et al., 2002). Psychoanalysis may benefit from careful assays that will marry the clinical interaction with the potential of concurrent brain imaging of both analyst and patient. Such findings will likely pave the road to the neural correlates of the core exchange.

Conclusion

Charcot asserted that suggestion could affect somatic response through dynamic lesions. Freud further propelled the idea that 'words' have the power to change brain function and influence physiology. Modern imaging tools carry dynamic lesions into a new 'behavioural lesion' model. While TMS demonstrates how bursts of high magnetic fields produce short-lived behavioural alterations, fMRI illuminates how words can influence minds. In concert with other experimental tools, these converging approaches elucidate how suggestion can unravel deeply ingrained processes (Raz et al., 2007a). In this regard, current investigation into the neurological correlates of suggestion seems to beckon century-old ideas (Gauld, 1992; Harrington, 2008; Makari, 2008; McHugh, 2006).

Psychoanalysis of yore (e.g. 1893) is different from the psychoanalytic concepts expounded on by later notable analysts (e.g. Fairbairn, Balint, and Bowlby). Nonetheless, the subsequent and ongoing notions regarding mind–brain (e.g. Brenner) as well as recent experimental support for analytic concepts and theories (e.g. Milrod) have hardly nibbled at the basic conundrum. On the one hand, psychological constructs such as attention bridge the lacuna between brain and behaviour and unite psychology with the brain sciences (Raz and Buhle, 2006), and studies with psychogenic patients argue for the role of unconscious processes (Halligan et al., 2000; Marshall et al., 1997). On the other hand, the nature of unconscious thoughts and psychoanalytical concepts such as the ego continue to resist experimental robes. As a result, it is difficult to build tangible connections across the gap between the self and the ego. In developing psychoanalysis, Freud envisaged it to support a conduit to a nascent field of neuroscience. Ironically, now that neuroscience has matured, many psychoanalysts have moved further away in their interests and perhaps even passed into another realm (Michels, 2008).

Cognitive neuroscience may implicitly have a place for the ego as a conceptual construct. For Hartman as for Freud, the ego represented a number of executive-like functions. These functions—attention being one such exemplar—seem to coincide with the current view of neural control networks. Unlike 'representations', such as the self, these higher brain functions appear to be psychological 'transactions'. Cognitive neuroscience, however, often bowdlerizes the meaning of central psychoanalytical concepts, and thus the two fields approach certain issues orthogonally. For example, many neuroscientists have taken the term 'conflict' and transformed it from one of opposing forces, usually involving emotional or motivational undercurrents, into a mild inhibition of a prepotent response in the context of a cognitive paradigm. In the classic Stroop task, for example, little opposition exists in any strictly psychological sense, and it may therefore be difficult to generalize from these Stroop data to true emotional conflict of powerful opposing forces. Some scientists do investigate conflict in the emotional sense; for instance, recent experimental and neuroimaging data of paralysed stroke patients undergoing a Stroop-like task while viewing emotionally laden material related to their debility indicates unconscious defences are at work (Fotopoulou et al., 2010). This type of research is still the exception rather than the norm.

Many analysts have fallen into the trap of comparing modern brain imaging to nineteenth century phrenology (Uttal, 2001). This is a detrimental position, however, because it demonstrates a profound misconception of neuroimaging technologies and estranges the few scientists who might best promote the credibility of psychoanalysis (Posner, 2003). In addition, the psychoanalytic community should heed at least two warnings. The first is that research on suggestion can only partially support Freudian notions (Michels, 2008). While it may be tempting to select from and focus on findings that seem to support a specific viewpoint, such an approach confounds confirmatory with exploratory investigation (Raz, 2008b). The second is that many psychoanalytic concepts are unlikely to be reducible to brain mechanisms. Hence, the marriage of psychoanalysis with neuroscience must rely on a judicious grasp of the relative merits and shortcomings of brain imaging technology. Depending on the interpretation of output from a brain scanner, the result may be highly scientific or ambiguous and accommodating of a large number of possible outcomes.

Karl Popper's 'falsifiability criterion' posits that a theory is truly scientific, as opposed to non-scientific or pseudo-scientific, if the proposition retains the possibility of showing it false. The history of science reveals, however, that many theories were unfalsifiable initially. We can distinguish between two types of theories in this category. Theories of the first type lacked falsifiability because they were insufficiently operationalized in terms of measurable variables (e.g. psychoanalysis), whereas theories of the second type were unfalsifiable because they were underdeveloped. Even short of full development, however, those latter theories served a valuable heuristic purpose in generating a large body of useful research from which new theories and empirical findings could evolve. Extensions and revisions to psychoanalytic theory will likely permit its transition from the first to the second type of theories, allowing for more testable predictions as additional research increasingly draws on new methodologies, including behavioural lesions, TMS, and fMRI. As neuroimaging studies begin to elucidate the neural correlates of culture (Han and Northoff, 2008), converging findings to unlock the power of suggestion will likely pave the road to

Box 19.4 Questions for future study

1. How might we study concepts such as transference and countertransference via neuroscientific methods?
2. Could a behavioural lesion ever be so powerful as to be unreversible—in effect creating Charcot's image of a dynamic lesion?
3. If we were able to create neuroimaging tools so precise and powerful that they could pinpoint psychoanalysis at work in the brain, how would psychoanalytic treatment change?

a more scientific understanding of psychosocial factors in medicine, with special relevance to discerning such domains as placebo, psychotherapy, and psychoanalysis. We believe that our work on suggestion forges a potential model for research showing the convergence between psychoanalytic theory and neuroscience investigations.

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