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Review article

New directions in hypnosis research: strategies for advancing the cognitive and clinical neuroscience of hypnosis

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Abstract

This article summarizes key advances in hypnosis research during the past two decades, including (i) clinical research supporting the efficacy of hypnosis for managing a number of clinical symptoms and conditions, (ii) research supporting the role of various divisions in the anterior cingulate and prefrontal cortices in hypnotic responding, and (iii) an emerging finding that high hypnotic suggestibility is associated with atypical brain connectivity profiles. Key recommendations for a research agenda for the next decade include the recommendations that (i) laboratory hypnosis researchers should strongly consider how they assess hypnotic suggestibility in their studies, (ii) inclusion of study participants who score in the middle range of hypnotic suggestibility, and (iii) use of expanding research designs that more clearly delineate the roles of inductions and specific suggestions. Finally, we make two specific suggestions for helping to move the field forward including (i) the use of data sharing and (ii) redirecting resources away from contrasting state and nonstate positions toward studying (a) the efficacy of hypnotic treatments for clinical conditions influenced by central nervous system processes and (b) the neurophysiological underpinnings of

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Highlights

- Hypnosis treatments have demonstrated efficacy for a number of conditions.
- Research supports the role of divisions in the anterior cingulate and prefrontal cortices in hypnotic responding.
- Consideration of three study design issues could improve the impact of hypnosis research.
- Researchers in the field would do well to consider developing mechanisms for data sharing.
- It may be time to direct research resources away from studies that contrast state and non state models of hypnosis.

hypnotic phenomena. As we learn more about the neurophysiological mechanisms underlying hypnosis and suggestion, we will strengthen our knowledge of both basic brain functions and a host of different psychological functions.

Key words: consciousness; hypnosis; hypnotic suggestibility; hypnotizability

Introduction

In August of 2015, the International Society of Hypnosis and Confédération Francophone d'hypnose et Thérapies Bréves co-sponsored a 1-day meeting among hypnosis researchers, just before the International Congress of Hypnosis in Paris, France. One of the goals of the meeting was to discuss the state-of-the-science of hypnosis research from the purview of clinical and cognitive neuroscience. The purpose of this article is to summarize the key issues that were raised during the discussions, including the points of agreement and disagreement among the participants (all of whom are authors on this article). Here we first briefly summarize what we view as (i) the most important research findings and developments in the field during the past two decades and (ii) the most salient challenges facing contemporary hypnosis research. Next, we summarize our discussion concerning directions for future hypnosis research and collaborative endeavors that could expand upon recent advances, address emerging challenges, and facilitate a reemergence of hypnosis research as a vital field within cognitive and clinical neuroscience.

Recent Advances in Hypnosis Research

There are two major approaches to hypnosis research: (i) "intrinsic" hypnosis research, where the focus is to understand the nature of hypnosis itself and (ii) "instrumental" hypnosis research in which hypnosis and hypnotic suggestions are used to produce effects of interest to researchers outside of the field of hypnosis (Reyher 1962; Cox and Bryant 2008; Oakley and Halligan 2009). With respect to the first category, significant gains have been made in the past two decades regarding our understanding of the neurophysiological correlates of hypnotic responding (i.e. responding to hypnotic suggestions) and in our understanding of the efficacy of hypnotic treatments for various clinical conditions (Oakley and Halligan 2013; Elkins 2017; Terhune *et al.* 2017). In instrumental hypnosis research, the major focus has been the use of hypnosis to model psychiatric conditions.

Neurophysiological correlates of hypnotic responding

Some of the most theoretically substantive findings during the past two decades have come from studies that have sought to identify the neurophysiological bases of individual differences in preparation for responding to suggestions (i.e. responses to hypnotic inductions) and response to hypnotic suggestions in general (i.e. the trait of hypnotic suggestibility or hypnotizability), as well as those underlying response to specific hypnotic suggestions (Oakley and Halligan 2009; Oakley and Halliagan 2010; Oakley and Halligan 2013). For example, McGeown *et al.* found that response to a hypnotic induction is associated with a greater selective reduction of resting state medial prefrontal cortex activity [as measured by functional magnetic resonance imaging (fMRI)] in individuals who scored high on a measure of hypnotic suggestibility (highs) than those who scored low [lows; McGeown *et al.* (2009), see also Demertzi *et al.* (2011); Deeley *et al.* (2012); McGeown *et al.* (2015); Jiang *et al.* (2016)].

Relatedly, multiple studies utilizing resting state electroencephalography (EEG) have shown that after an induction, highs exhibit reduced functional connectivity – particularly in frontal structures – than lows and that such effects relate to spontaneous changes in conscious states (Terhune *et al.* 2011; Cardeña *et al.* 2013; Jamieson and Burgess 2014) [see also Egner *et al.* (2005)]. Functional connectivity studies using fMRI have also demonstrated differences in the brain networks of highs (Hoeft *et al.* 2012; Huber *et al.* 2014), and structural MRI research suggests that highs exhibit greater volume in the rostrum of the corpus callosum (Horton *et al.* 2004) and medial prefrontal and anterior cingulate cortices (Huber *et al.* 2014; McGeown *et al.* 2015). There is also preliminary research indicating that hypnotic responding might be enhanced by procedures which selectively reduce activity in the prefrontal cortex, suggesting that inhibiting psychological functions supported by this region may enhance response to suggestion (Dienes and Hutton 2013; Semmens-Wheeler *et al.* 2013; De Pascalis *et al.* 2015). Cumulatively, these results suggest pivotal roles for regions of the prefrontal and anterior cingulate cortices in hypnotic suggestibility and in differential response to hypnotic inductions.

A major development with the advent of cognitive neuroscience and the application of neuroimaging methods to hypnosis has been the validation of participants' subjective responses to hypnosis (Oakley and Halligan 2013). Traditionally, psychologists and neuroscientists have been skeptical of hypnosis and distrustful of participants' subjective reports of profound changes in perception following specific suggestions. Although the neurophysiological mechanisms underlying hypnosis have yet to be thoroughly delineated, neuroimaging research has consistently demonstrated that subjective changes in response to suggestion are associated with corresponding changes in brain regions related to the specific psychological function in question (Kosslyn *et al.* 2000; Derbyshire *et al.* 2004; Cojan *et al.* 2009; Demertzi *et al.* 2011; McGeown *et al.* 2012; Demertzi *et al.* 2015). For example, these and other studies have demonstrated similar cortical activation patterns between suggested experiences (e.g. pain reduction) and the corresponding perceptual states and further shown that the effects of suggestion are distinct from those of imagination. This research has allowed researchers to move beyond basic questions pertaining to the validity of participants' subjective responses to more sophisticated questions regarding mechanisms.

Theoretical and empirical advances indicate that hypnotic suggestibility may be composed of both a core ability as well as ancillary componential abilities [e.g. Woody *et al.* (2005)]. Multiple independent lines of research have begun to clarify the different components of hypnotic suggestibility and their neurophysiological mechanisms. For example, researchers have examined the mechanisms underlying perceived involuntariness of ideomotor suggestions [e.g. Blakemore *et al.* (2003); Deeley, Walsh *et al.* (2013)]. Importantly, this work is informed by and has the potential to inform broader theories of motor control in the central nervous system [see e.g. Blakemore *et al.* (1998)]. For instance, Jamieson (2016) has shown that these findings can be incorporated within predictive coding models of motor control (Friston 2010) which may be readily extended to provide a general model of hypnotic suggestion.

Cojan *et al.* observed that suggested paralysis differs from active voluntary motor inhibition by modulating cortical activity in precuneus, thereby potentially implicating imagery and self-monitoring functions in the implementation of this suggestion (Cojan *et al.* 2009). Such cortical modulation was further accompanied by decreases in functional connectivity between primary motor cortex and premotor areas but increased connectivity between primary motor cortex and precuneus (Cojan *et al.* 2009) [see also Deeley, Oakley *et al.* (2013); Deeley, Walsh *et al.* (2013)]. It will be necessary to distinguish neurophysiological effects that relate to a core ability conferring a general level of hypnotic suggestibility from those that underlie ancillary specialized abilities that enable responsiveness to specific suggestions (Woody and McConkey 2003).

Hypnotic analgesia has been further investigated by a range of neuroimaging methods including positron emission tomography (PET) (Faymonville *et al.* 2003), EEG (De Pascalis and Perrone 1996; Miltner and Weiss 2007), somatosensory event-related potentials (ERPs) (De Pascalis *et al.* 2001; De Pascalis *et al.* 2008; Williams *et al.* 2010), and fMRI (Derbyshire *et al.* 2009; Vanhaudenhuyse *et al.* 2009). Such studies have shown that hypnotic suggestions can have specific localized effects by influencing activity in cortical and sub-cortical regions thought to be associated with suggested analgesia response [e.g. Hofbauer *et al.* (2001); Rainville *et al.* (1997)]. These studies also point to an important role of medial and lateral prefrontal and parietal cortices [now understood as hubs of network regulation (Raichle 2011)] in hypnotic responding, with substantive implications for the clinical treatment of pain.

Preliminary research further suggests a possible role for the cerebellum in hypnotic suggestibility (Santarcangelo and Scattina 2016). For example, highs appear to display less precise control of movement and posture by sensory re-afferences and absence of motor learning perhaps due to less efficient cerebellar control (Menzocchi *et al.* 2015). They also show paradoxical pain modulation following transcranial cerebellar anodal stimulation (Bocci *et al.* 2016). Cumulatively, the body of research discussed so far indicates that the perceived effects of hypnosis and hypnotic suggestion have clear impacts on brain activity (in particular, the activity known to underlie the perceived effects), supporting that these effects are "real"; hypnotic subjects are not merely pretending when they report profound changes in their experience due to hypnosis. This research has also begun to help us understand the brain areas and activity patterns which underlie hypnotic responding in general and response to specific hypnotic suggestions.

Clinical trials evaluating the efficacy of hypnosis treatments

In addition to advances in basic research in the neuroscience of hypnosis, there was a consensus agreement by the symposium participants that there have been important developments in our understanding of the efficacy of hypnosis for treating a variety of clinical conditions. This research has been summarized in a number of influential systematic reviews and meta-analyses, which show the strongest empirical support (to date) for the use of hypnosis treatments for pain (Patterson and Jensen 2003; Hammond 2007; Tome-Pires and Miro 2012), irritable bowel syndrome (Schaefert *et al.* 2014), and post-traumatic stress disorder (PTSD) symptoms (Rotaru and Rusu 2016). Limited evidence – to be confirmed by larger scale clinical trials –suggests that hypnotic treatments may also be effective for a wide variety of other problems and conditions such as depression (Alladin and Alibhai 2007), anxiety (Hammond 2010), and problem smoking (Lynn *et al.* 2010). In addition, research indicates that hypnosis and hypnotic techniques can be combined with nonhypnotic treatments to enhance the efficacy of the latter (Kirsch *et al.* 1995; Jensen *et al.* 2011). We anticipate that future research will aim to integrate clinical and basic science results to further strengthen the application of hypnosis in clinical contexts and study the mechanistic basis of therapeutic suggestions.

Using hypnosis to model psychiatric symptoms

Numerous studies have further demonstrated the potential opportunities for using hypnotic suggestion in an instrumental manner to model psychiatric and neurological symptoms. Hypnosis has been used in neuroimaging and behavioral contexts to model auditory hallucinations (Szechtman *et al.* 1998), visual hallucinations (Kosslyn *et al.* 2000; McGeown *et al.* 2012), conversion-like symptoms (Cojan *et al.* 2009; Deeley, Oakley *et al.* 2013; Deeley, Walsh *et al.* 2013), amnesia (Mendelsohn *et al.* 2008), and delusions (Cox and Barnier 2010; Connors *et al.* 2015).

A further line of research points to the value of hypnotic suggestion in modulating cognitive control processes (Raz *et al.* 2006), which supports the instrumental use of hypnosis for studying psychopathology in a controlled environment (Woody and Szechtman 2011). Neuroimaging research in this area has highlighted both overlapping and differential activation patterns between hypnotic analogues of particular symptoms or states and the modeled phenomenon, thereby reinforcing the value of this approach but also suggesting important avenues for further research (Vuilleumier 2014).

Current Challenges in Hypnosis Research

Despite a range of recent advances in hypnosis research, there was also a sense among participants that this field has lost some of the direction and momentum that had been growing until the early 1990s. This change may be due in part to the loss of a number of influential researchers who were very active in the preceding decades [e.g. André M. Weitzenhoffer (1921–2004), Ernest R. Hilgard (1904–2001), Martin Orne (1927–2000), Theodore X. Barber (1927–2005), Kenneth S. Bowers (1937–1996), Nicholas P. Spanos (1942–1994), Theodore Sarbin (1911–2005), and William Coe (1930–2004)]. These were not only highly productive individual researchers, but leaders of research programs within the field and closely associated institutional research centers. All were senior academics with a high level of status both within and outside of their institutions. When these researchers retired, their respective research centers lost their institutional "champions" and were no longer able to draw the necessary levels of research funding or institutional support. Following the loss of the leading research centers, hypnosis research became a largely individual pursuit. This has been associated with a loss of agreement on common problems and on how to recognize research progress.

A further challenge confronting the field is that hypnosis research continues to be seen as taboo or unscientific within some elements of the broader scientific community. Such perceptions, which we maintain are unfounded and driven by the inaccurate (and often outlandish) portrayal of hypnosis in the media and popular culture rather than a sober consideration of clinical and experimental data (Nash 2001; Raz 2011; Polito *et al.* 2016), have a number of potentially significant negative consequences including a potential decline in funding for hypnosis research. Potential contributing factors include the field's association with stage hypnosis (Echterling and Whalen 1995), the inaccurate portrayal of hypnosis in popular culture ("Popular beliefs and scientific facts," 2014), and controversies regarding hypnosis and memory (Winter 2013).

However, two recent trends suggest that the misperceptions about hypnosis may be becoming less of an impediment to research progress. First, the National Institute of Complementary and Integrative Health at the National Institutes of Health in the USA now recognizes hypnosis as a topic of interest, and has begun to fund large-scale studies evaluating the efficacy and mechanisms of hypnosis treatments. In addition, papers on hypnosis are now commonly found in high impact factor journals [e.g. Cojan *et al.* (2009); Hoeft et al. (2012); Jensen et al. (2014); Mendelsohn et al. (2008); Oakley and Halligan (2009, 2013)]. Nevertheless, despite this apparent increase in the acceptance of hypnosis in some settings, hypnosis remains less accepted as a topic of research than other similar phenomena, such as meditation. One of the purposes of this article is to outline steps that could be made by researchers in the field to help better establish hypnosis research as a respected and important endeavor.

Another challenge identified by the group is that although there are many active hypnosis researchers in different parts of the world, there is a general lack of organized ongoing collaboration and critical exchange between researchers. Relatedly, independent researchers typically target different features of hypnosis rather than collectively focus on a coherent set of core questions. This environment limits the impact of particular research programs and also leaves differences in important findings unresolved. Moreover, the group noted a lack of new comprehensive theories of hypnosis that make unexpected or novel predictions or address heterogeneity at different levels of hypnotic suggestibility [e.g. Pekala and Kumar (2007); Terhune (2015)] or how hypnosis relates to suggestion more broadly [e.g. Halligan and Oakley (2014); Meyer and Lynn (2011); Santarcangelo *et al.* (2016); Scattina *et al.* (2012)]. A relative lack of theory development represents an impediment to the continued development of our scientific understanding of hypnosis, including its integration into broader models of human cognition.

Addressing the Challenges of Contemporary Hypnosis Research

Much of our discussions focused on strategies for addressing the foregoing challenges. The recommendations that emerged fell into three broad categories: (i) high priority goals for research in the next decade; (ii) use of appropriate research designs; and (iii) communication and collaboration between researchers.

Recommendations regarding high priority goals for hypnosis research in the next decade

Three topic areas were discussed in relation to the issue of high priority goals for hypnosis research: (i) the neurobiological underpinnings of hypnotic suggestion; (ii) the importance and impact of hypnotic inductions; (iii) and grounding hypnosis research in theory and relating it to germane phenomena.

The biological underpinnings of hypnotic suggestion and hypnotic suggestibility

Although research on the biological underpinnings of hypnotic suggestion has begun to identify the role that different brain structures and networks have in generating responses to specific forms of hypnotic suggestions, we believe that an important focus in the next decade of intrinsic hypnosis research should be advancing the chain of explanation to identify the mechanisms that enable, facilitate, initiate, or terminate the operation of the specific functional mechanisms engaged by different types of hypnotic suggestions. In particular, we believe it is imperative to further study different types of suggestions, such as motor, perceptual-cognitive, and hypnotic amnesia, each of which may have discrete properties (Woody *et al.* 2005), to identify their shared and distinct mechanisms and characteristics. This research should endeavor to isolate and further clarify heterogeneity in hypnotic responding, including the potential roles of different cognitive functions in distinct subgroups of lows, mediums (see the section, later in this article, on the importance of studying mediums), and highs (Barber 1999; Terhune *et al.* 2011). Such research should focus on a number of underlying systems and processes, including the effects of hypnotic suggestions on activity in specific areas of the brain (De Pascalis and Russo 2013), changing patterns of functional connectivity between brain areas or within and between networks (Cojan *et al.* 2009; Jiang *et al.* 2016), and the functional role of different frequencies of brain oscillations (De Pascalis *et al.* 2004; De Pascalis 2007; Jensen *et al.* 2015).

We also agreed that identification of the neurophysiological differences underlying individual differences in trait hypnotic suggestibility (Laurence *et al.* 2008), as measured by the most reliable and valid existing hypnotic suggestibility scales, is essential for the future progress of the field. The goal here is to establish a reliable foundation of shared knowledge, across labs and cultures, upon which future advances may be built. We anticipate that such basic research will help to establish a solid foundation for the development and evaluation of wider neurobiological theories of the impact of hypnotic inductions and response to hypnotic suggestions.

The importance and impact of hypnotic inductions
A "hypnotic induction" can be understood as a procedure or initial suggestion designed to – or at least believed to – prepare an individual for the suggestions that follow by increasing his or her ability or tendency to respond to the suggestions (Nash 2005). Although inductions can vary in many ways, from being very brief (seconds) to much longer (10–20 minutes or longer), and include either more passive approaches involving suggestions for eye closure and feeling increasingly relaxed or more active approaches involving keeping the eyes open and remaining very alert, most inductions ask the subject or client to focus his or her awareness on an object (e.g. spot on the wall) or experience (e.g. breathing or self-generated images) and to become deeply absorbed in that focal point [for recent discussions of inductions, see Kumar (2016); Reid (2016); Terhune and Cardeña (2016); Woody and Sadler (2016)].

During our discussions, there was a consensus that hypnotic inductions result in a measurable increase in response to the suggestions that follow the induction. However, scientists differ with respect to the overall importance of an induction as being a necessary (or impactful) component of hypnosis. Some view the induction as playing a relatively small role in hypnosis. Research using standardized hypnotic suggestibility instruments with and without inductions supports such a view (Hilgard and Tart 1966; Braffman and Kirsch 1999; Derbyshire *et al.* 2009; Meyer and Lynn 2011). In contrast, other research has demonstrated pronounced effects of inductions on response to specific types of suggestions [e.g. Connors *et al.* (2015)]. The sources of these inconsistencies are not yet known (Terhune and Cardeña 2016). Furthermore, virtually all definitions of hypnosis include an induction as a component of hypnosis and hypnotic procedures [e.g. Elkins *et al.* (2015); Green et al. (2005); Kihlstrom (1985)], consistent with the idea that the induction continues to be viewed as an important part of hypnosis procedures for the majority of clinicians and researchers.

Either way, relatively little research has been directed toward isolating the specific features of an induction that may augment suggestibility; we anticipate that further research on such a question will have significant benefits for both basic and clinical science (Brown *et al.* 2001; Burke *et al.* 2003). Specifically, our scientific understanding of hypnosis will be bolstered by further research on the importance and impact of inductions, their component features, and their role in response to suggestion and how this impact is moderated by trait hypnotic suggestibility. For example, does an induction lead to a heightened state of preparation for responding to suggestions, somewhat like the "get set" command that precedes the runners' "go" signal? If so, what is the mechanism whereby this facilitation occurs?

Relating hypnosis to germane phenomena
An important step in relating hypnosis to broader psychological phenomena will include bridging empirical and phenomenological studies of hypnosis and germane phenomena. For example, it is imperative that researchers study hypnosis and meditation in conjunction to map their similarities and differences. This discussion was initiated by the recent surge of scientific interest in both hypnosis and contemplative practices such as mindfulness meditation (Oakley and Halligan 2013; Tang *et al.* 2015). There is already a tradition of scholars proposing conceptual and phenomenological links between hypnosis and meditation (Davidson and Goleman 1977; Halsband *et al.* 2009; Lifshitz *et al.* 2012) yet there remains a paucity of empirical studies directly comparing the two sets of practices (Morse et al. 1977; Lush *et al.* 2016).

Despite different historical trajectories and sociocultural contexts, hypnosis and meditation, both originated as practices of attention and self-regulation designed to ease suffering (Lutz *et al.* 2008; Lifshitz *et al.* 2012; Raz and Lifshitz 2016). Psychotherapists and clinicians use both to treat similar types of conditions, such as major depression (Lynn *et al.* 2010; Segal et al. 2010; Alladin 2014), acute or chronic pain (Patterson and Jensen 2003; Chiesa and Serretti 2011), and substance abuse (Barnes *et al.* 2010; Brewer *et al.* 2010). Although renewed scientific interest has brought hypnosis and meditation into the scientific and clinical mainstream, their relationship – including their relative efficacy for treating different conditions – remains poorly understood. During our discussion, we considered the commonalities in the mechanisms of hypnosis and meditation in analgesia, and the methodological need to develop more fine grained phenomenological models comparing these unique phenomena.

A further challenge in relating hypnosis and meditation is posed by the need to apply a neurophenomenological approach to rigorously describing and preserving the complexity and nuances of lived experience during these practices and integrating this with neurophysiological data (Lutz and Thompson 2003). To address these conceptual issues, Markovic and Thompson recently proposed the use of a more general model of phenomenal states as a tool to identify and describe both the shared features and the differences in meditation and hypnosis (Markovic and Thompson 2016). This phenomenal model has also been presented as a heuristic for mindfulness meditation research and interpreted in relation to a neurocognitive matrix constituted by several large-scale functional networks – such as the central executive network and the salience network, or the default mode network (Lutz *et al.* 2015; Jiang *et al.* 2016). Research is further needed to evaluate the utility of such "bridging" models of hypnosis and other related phenomenon, such as placebo responsiveness [cf. De Pascalis and Scacchia (2016); Sheiner *et al.* (2016)].

Recommendations for improving the methodological rigor of hypnosis research

Measuring hypnotic suggestibility
The pronounced interindividual differences in hypnotic suggestibility have been known ever since the formal inception of hypnosis in the 19th century (Laurence *et al.* 2008). The development of reliable measures of hypnotic suggestibility helped to usher in a nascent era of rigorous research on hypnosis in the 20th century (Hilgard 1965) and are widely seen as an integral feature of experimental hypnosis research (Woody and Barnier 2008). Nevertheless, disagreement regarding when and how to include hypnotic suggestibility measures in experimental studies persists. In addition, as the study of hypnosis has continued within the broader domains of clinical and cognitive neuroscience, questions regarding the efficacy of standardized measures of hypnotic suggestibility (Weitzenhoffer 1980; Bowers 1982; Sadler and Woody 2004; Woody and Barnier 2008; Terhune 2015) are re-emerging.

A lingering question that is of considerable importance for the neuroscience of hypnosis is whether the assessment of hypnotic suggestibility is a requisite for hypnosis research. Disagreement in the answer to this question typically falls along clinician-practitioner lines. Many clinicians maintain that it is not necessary for an individual patient to be highly suggestible for them to respond to, and/or benefit from, hypnotic suggestions. For example, a meta-analysis of clinical trials revealed only a weak, albeit statistically significant, association between measures of hypnotic suggestibility and treatment outcome (Montgomery *et al.* 2011). These results arguably question the practical necessity of including such measures in clinical settings, especially for use to screen patients for exclusion from treatment with hypnosis.

However, the low predictive efficacy of hypnotic suggestibility appears to be restricted to the clinical context; in experimental contexts, hypnotic suggestibility is more strongly and more consistently predictive of responsiveness to suggestion (Oakley and Halligan 2013; Woody *et al.* 2005). These discrepancies plausibly arise from the greater number of factors that contribute to treatment outcome in clinical contexts relative to experimental contexts, such as patient/participant motivation. In addition, clinical treatments often include multiple sessions that are provided over many weeks, which may increase the opportunity for treatment-related factors that are not specific to hypnosis to impact outcome. Moreover, multiple hypnosis sessions – especially if they are accompanied by daily home practice of self-hypnosis – provide the individual with increased exposure to suggestions. Hearing suggestions repeatedly could potentially then translate to beneficial outcomes even among individuals with low levels of hypnotic suggestibility.

Although the clinical use of hypnosis should undoubtedly aim to maximize treatment outcome for patients, in an experimental context aiming to identify the neural substrates of hypnotic responding, there was consensus in our symposium that it is necessary to isolate the factors that contribute to response to specific suggestions as precisely as possible. A positive response to a hypnotic suggestion may occur through a multitude of channels; but if that response is related to a measure of hypnotic suggestibility there can be some corroboration that the outcome was caused, at least in part, by a *hypnotic* suggestion. This also applies to research investigating the impact of a hypnotic induction without specific suggestions, where hypnotic suggestibility will still predict responses (Pekala and Kumar 2007; Cardeña *et al.* 2013). For this reason, many researchers subscribe to Bowers' doctrine – the position that any effect that is unrelated to hypnotic suggestibility should not be identified as a hypnotic effect (Woody and Barnier 2008). Thus, although we accept the justification for omitting hypnotic suggestibility scales in clinical outcome studies because of their poor predictive validity in clinical contexts (Patterson and Jensen 2003), we strongly recommend that laboratory experiments aiming to identify the neurocognitive substrates of hypnotic responding include measures of hypnotic suggestibility so as to maximize identification of suggestion-specific responses and thereby strengthen the internal validity of the study.

Although we view hypnotic suggestibility as an essential feature of experiments aiming to delineate the characteristics and mechanisms of hypnotic responding, there remain questions regarding the validity of established measures. Hypnotic suggestibility scales are typically used in two complementary ways: as instruments for (i) screening participants and (ii) identifying individuals of varying levels of hypnotic suggestibility for measuring trait hypnotic suggestibility as a dependent or predictor variable. Although both uses assume the construct validity of standardized measures of hypnotic suggestibility, the second more clearly necessitates it. That is, there is an assumption that even though no measure is perfectly reliable and valid, a measure of hypnotic suggestibility will still be able to reasonably identify highly suggestible individuals (i.e. most measured as highs will be genuine highs). However, the introduction of noise into a measure, such as by conflating involuntary and compliant responses in a single score (Bowers *et al.* 1988), and the concomitant reduction in its precision, has the potential to substantially attenuate correlations with other measures.

Hypnosis researchers continue to use measures of hypnotic suggestibility that were developed more than five decades ago (Shor and Orne 1962; Weitzenhoffer and Hilgard 1962, 1963) and this raises questions regarding whether the rigor of hypnotic suggestibility measurement properly matches the rigor of contemporary behavioral and neuroimaging paradigms. Although traditional scales can be considered the gold standard for the time period in which they were developed, there is growing evidence that they may be suboptimal for contemporary research purposes. For example, there is evidence that group measures, which are more widely used as stand-alone measures for the assessment of hypnotic suggestibility (Barnier and McConkey 2004), are inferior to individual measures in the prediction of response to suggestion (Moran *et al.* 2002). The pool of items in such measures is also poorly-suited to probing individual differences in hypnotic suggestibility (Woody and Barnier 2008; Terhune 2015). An additional substantial limitation is that these measures do not reliably distinguish between voluntary and involuntary responding (Weitzenhoffer 1980; Bowers *et al.* 1988), thereby calling into question their construct validity. Future measures will need to more optimally integrate behavioral and experiential measures, rather than focusing solely on the former (Bowers *et al.* 1988; Pekala and Kumar 2007).

We maintain that the expansion of standard measures of hypnotic suggestibility to incorporate broader phenomenological changes, such as distortions in body image, time perception (Pekala and Kumar 2007), and sensorimotor integration (Santarcangelo and Scattina 2016), will be particularly valuable. Further concerns with existing measures are that (i) they do not distinguish between direct (e.g. "Your arm is getting heavier ...") and indirect (e.g. "... and I wonder if you might be starting to notice a change in your arm ....") suggestions, (ii) they do not consider the operation of different response strategies or cognitive styles (Sheehan and McConkey 1982; Winkel *et al.* 2006), and (iii) they do not include suggestion content that is directly relevant to many contemporary research questions (e.g. attention, pain). The development of future measures of hypnotic suggestibility will benefit from a more thorough consideration of such issues.

Mapping the full spectrum of hypnotic responding

Most (but not all) hypnosis research designs select participants on the basis of hypnotic suggestibility, usually to assess the impact of hypnotic suggestibility on responses to some specific suggestion or to ensure a sufficient level of susceptibility to produce the phenomena under investigation. From about 1960 to 1990, studies conducted at the major centers of hypnosis research routinely included highs, mediums, and lows in their research designs. Consistent with the idea that hypnotic suggestibility represents a continuum (and not discrete categories of responding), research often produced intermediate results for mediums [e.g. Sheehan *et al.* (1991)]. As a result, and given the resources required to both screen and test mediums, researchers determined that those resources would be better placed in expanding the sample sizes of highs and lows. In addition, for intrinsic hypnosis research that focused only on specific hypnotic hallucination suggestions – a response that requires very high levels of hypnotic suggestibility – there was no perceived value in including a further comparison group composed of lows who would be unable to respond to these suggestions. However, it remains possible that mediums may differ in important qualitative ways from both highs and lows. For example, differences between highs and mediums have been found in EEG patterns in response to a simple hypnotic induction (Crawford *et al.* 1993; De Pascalis 1993; McCormack and Gruzelier 1993). Without a group of medium responders, the evaluation of these differences is not possible. In addition, extreme lows and highs are atypical; most people are mediums (Lynn *et al.* 2007). As a result, in studies comparing lows and highs [e.g. Horton *et al.* (2004)], the findings cannot always be properly interpreted; for example, it is not possible to determine if any between-group differences found are due to highs being atypical or lows being atypical (Lynn *et al.* 2007). If neurophysiological differences are observed between mediums and highs, it is a reasonable inference that the latter are the atypical group. As neuroscience research on hypnosis continues to investigate the neurophysiological correlates and markers of high hypnotic suggestibility we hope that greater attention is afforded to such nuances.

It is ironic then that some recent research designs in the neuroscience of hypnosis have dropped even the low suggestible comparison group, using instead only high suggestible subjects acting as their own controls (Oakley and Halligan 2010). There are several reasons for this. First, in neuroimaging studies scanner time is simply too expensive to include participants who do not show the phenomenon under investigation. Second, based on the experience of many of the authors, it is becoming progressively more difficult in the modern university environments to recruit, screen and run the numbers of participants required for study designs with multiple levels of hypnotic suggestibility. Third, the blanket rejection by many journals of perceived low powered studies leads researchers to perform experimental manipulations on a single high susceptible group rather that split this difficult to obtain group into those who do and do not show the phenomenon in question, as was done in earlier neuroimaging studies (Szechtman *et al.* 1998). Whereas few researchers have the luxury to ignore these pressures, it must be recognized that none of these design trends would have been considered acceptable in the previous era of behaviorally dominated research.

Variability in the pattern of hypnotic responses among individuals with the same overall level of suggestibility has long been recognized. The *Stanford Profile Scales* (Weitzenhoffer and Hilgard 1962, 1963) were designed to address this feature among highs although they have been little used in practice. Shor (1979) and Sheehan and McConkey (1982) developed first-person interview methods to further assess these differences. Whereas these methods focused on individual heterogeneity in responses, later researchers sought to identify meaningful groupings of individuals and responses within these patterns of variability (Pekala and Kumar 2007), including among mediums (Winkel *et al.* 2006; Terhune *et al.* 2017), and highs (King and Council 1998; Terhune *et al.* 2011). Although many would agree with Kihlstrom (2015) that definitive findings will require the compilation of larger datasets than currently available, these and other research findings support the idea that distinct patterns of hypnotic responding seem to exist within high, medium, and low suggestible groups. This fruitful program of contemporary hypnosis research has no counterpart in the neuroscience of hypnosis. One way to advance this program is to carefully select and compare low, medium, and high suggestible individuals chosen not simply for their global hypnotic suggestibility scores but rather for specific patterns of responsiveness to different types of hypnotic suggestions (or other characteristics). While the recruitment of subjects with a variety of hypnotic abilities is important for understanding the nature of hypnosis in general (i.e. in intrinsic hypnosis research studies), such recruitment is less relevant to instrumental studies that seek to use hypnosis as a tool to understand nonhypnotic phenomenon. For example, researchers wanting to study psychiatric conditions (or symptoms) that can be modeled with hypnosis may require mostly or even only highs.

The importance of the "suggestion only" condition

A large number of neuroimaging studies of hypnosis [for reviews see Mazzoni *et al.* (2013); Oakley and Halligan (2010)] have adopted research designs that confound the two principal situational components of hypnosis: (i) the induction and (ii) the provision of suggestions following the induction. That is, many experiments contrast data from some condition of interest (e.g. Stroop task, pain stimulation) in individuals who are administered both components of hypnosis with (usually the same) individuals who are administered neither. It is important to consider the types of questions such a study design can answer. This design is acceptable if one wants to determine whether hypnotic suggestions (i.e. suggestions given following an induction) can produce a particular effect on the experience or performance of some activity. Indeed, studies using this design have shown how hypnosis can produce specific changes in brain activation due to hypnotic suggestions [e.g. Halligan *et al.* (2000); Hofbauer *et al.* (2001); Rainville *et al.* (1997); Raz (2011); Willoch *et al.* (2000)]. However, one cannot determine from studies using this design that the effects are due to the induction alone, the suggestion alone, or (as is usually supposed) their interaction. Therefore, to claim that the effects observed are attributable to hypnotic suggestion (as distinct from suggestion alone) would be an overinterpretation as "no behavior following hypnotic induction can be attributed to hypnosis unless the investigator first knows that the response in question is not likely to occur outside of hypnosis in the normal waking state" (Sheehan and Perry 1976, p. 55).

To the extent that a hypnotic induction is viewed as a necessary component of hypnosis then, if we want to conclude that the effects observed in response to these suggestions are indeed due to hypnosis – i.e. require an induction to occur – it becomes necessary to use a valid control condition against which the effects of various types of hypnotic suggestions are measured; one important control condition is one in which no hypnotic induction is given prior to the suggestion. In other words, to examine the effects of hypnosis on response to suggestion in neuroimaging research, one needs to use experimental designs that disentangle the effects of induction of hypnosis on response to suggestions from the effects of the same suggestions given without the induction (Hull 1933; Maquet *et al.* 1999).

This decoupling is achieved by using designs in which the same suggestion is given with and without an induction, thus requiring the inclusion of a suggestion-only condition (Oakley and Halligan 2010). Oakley and Halligan (2010) and Mazzoni *et al.* (2013) propose a basic experimental design that is needed if the study seeks to understand the effects of a hypnotic induction procedure *per se* on suggestibility; specifically, a 2 (induction versus no induction) $\times$ 2 (suggestion given versus suggestion not given) design. Moreover, as stressed by Oakley and Halligan (2010), in this design it is essential that the wording of the suggestion be identical in all groups. Mazzoni and colleagues note that "... this basic design is capable of addressing a number of important questions. Perhaps the most important of these is whether the effects of suggestion require the induction of a hypnotic state" (Mazzoni *et al.* 2013, p. 402).

Strangely, this most basic 2×2 design has only been rarely used in cognitive neuroscience studies. However, researchers occasionally have used subsets of this design that meet the minimal criterion for evaluating the effects of inductions (e.g. the inclusion of at least two conditions in which all the variables are held constant except the presence versus absence of an induction). That is, designs which (i) compare "neutral hypnosis" condition (minimal induction without additional suggestion) to a control condition (no induction) or (ii) compare the effects of a suggestion given following an induction to those of the same suggestion administered without an induction (Mazzoni *et al.* 2013).

For example, brain activation following versus not following an induction has been compared using both simple pre-post induction [e.g. Rainville *et al.* (2002); Rainville *et al.* (1999)] and between subjects (high versus low susceptibility) factorial designs [e.g. Egner *et al.* (2005); see also Crawford *et al.* (1993)]. These studies have identified potential brain markers related to hypnotic inductions, but, as in the Egner *et al.* study (2005), no specific suggestion was examined. The Crawford *et al.* (1993) study is particularly interesting as it shows an effect of a hypnotic induction while participants were in a resting state. An "extended design" (Mazzoni *et al.* 2013) to investigate the effects of hypnosis and suggestion on brain activity was used in the research by McGeown *et al.* (2009, 2012; Mazzoni *et al.* 2013), in which the basic four-cell design was applied to both high and low suggestible individuals. The importance of including mediums in hypnosis research has already been discussed in this article, and including mediums in the extended design would represent an important addition to achieve a complete design that examines the brain activation linked to all three crucial variables in hypnosis: the effect of the individual level of suggestibility, of the specific suggestion, and of the hypnotic induction used.

Strategies for Moving the Field Forward

Data sharing

Research in other fields has benefited substantially from data-sharing initiatives. A relevant example is evident in genomics research, in which data pooling has, e.g., enabled knowledge of disease-related loci to be expanded substantially [e.g. Lambert *et al.* (2013); Manolio *et al.* (2008); Schizophrenia Working Group of the Psychiatric Genomics (2014)], findings which would not have been possible without the sample sizes offered through data-sharing.

Data-sharing is also likely to lead to knowledge enhancement in the areas of hypnosis and suggestibility research. If data from multiple labs are accessible, researchers could assess them using additional analytic methods that may offer further insights that would otherwise be missed. Replicability checks and comparisons could also be undertaken more easily. Given the absence of a data-sharing framework that is specific to research on hypnosis and suggestibility, a preexisting data-sharing option could be adopted. Although a number of these initiatives exist, to offer a practical suggestion and to attempt to consolidate data relating to hypnosis and suggestibility in one place, we currently suggest Zenodo (https://zenodo.org/),[1] which is provided and maintained by CERN. This initiative offers suitable flexibility for sharing various types of data (e.g. behavioral data, electrophysiological data, and neuroimaging data). Experimental procedures, paradigms, and software can also be shared. Any file format is accepted and uploads receive a Digital Object Identifier for citation purposes. For very large sets of data, additional links could be provided, e.g., to institutional repositories.

There are a number of different data-sharing models that could be adopted. For example, (i) data-sharing initiatives such as that outlined above can simply enable the exchange of data from different studies, whereas (ii) others would require a standard set of measures to be collected routinely across studies. The first option is the easiest to implement, the second option would require consensus within the field about what measures would be most useful (at least for an initial phase of data collection and sharing).

If a selection of uniform measures were to be collected across studies (in addition to study specific measures), an advantage of data-sharing is that the data might be pooled more easily, increasing statistical power and thereby potentially enabling subtle and previously undetectable findings to be identified. This may benefit studies in particular that focus on neuroimaging, which are costly and tend to have small sample sizes (Button *et al.* 2013), those that employ electrophysiological techniques that might be extremely time-consuming, or those that include genetics. Behavioral data are not precluded from the benefits of having uniform data-sets, however. To ensure methodological rigor, studies require not only uniform measures but uniform procedures (e.g. inductions).

To provide for standardization, here we propose a set of basic variables which we recommend hypnosis researchers assess. Specifically, we recommend that researchers routinely provide, when possible and "for each participant":

a. Basic demographics: At a minimum, age, years of formal education and sex/gender. When possible, researchers should also assess earlier experience of hypnosis and related phenomena (meditation), neurological/psychiatric symptoms, and present and past use of psychoactive drugs.
b. A clear statement regarding the hypnotic suggestibility scale that was administered, and the specific responses provided to each item on the scale, in addition to the summary score.
c. If the same hypnotic induction and suggestions were used for each participant, it would be beneficial to provide a verbatim script. If inductions and/or suggestions were individualized at some level, to enable other researchers to effectively use the data, it would help if researchers could report on the content of the induction for each participant using the following meta-data listings of the words or variations of the words used during the inductions: (i) hypnosis; (ii) relaxation; (iii) mental imagery; (iv) sleep; (v) eye closure; (vi) trance; (vii) mental relaxation or "letting go"; (viii) muscle relaxation; (ix) alert; (x) focused attention; and/or (xi) slowed breathing. If elements are included that have not been covered in this list, these should also be detailed. Generally, the more detailed the provision of data, the more useful it will be.

In the case of neuroimaging or electrophysiological studies, relevant meta-data should also be shared (e.g., information on the scanner hardware, scanning acquisition parameters, the elecroencephalography sampling rate, etc.).

In terms of barriers to data-sharing, in some cases scientists may be reluctant to make their data available at an early stage, but data-sharing ("open access" format) can take place after publication of the primary study findings (something which is increasingly being required by study sponsors, such as NIH in the USA, and/or encouraged by certain journals, such as *Psychological Science* and *Cognition*). Alternatively, if researchers do not believe they have had enough time to explore their data sufficiently and are concerned about not receiving credit for their efforts they could make the data available through a "closed access" option, where a description of the data can be provided on the database – which could reduce duplication of effort and may lead to requests for productive collaborations. A further barrier is that data-sharing needs to be considered in the project planning stage and the intention to share data should be detailed within ethics applications, participant information sheets, and consent forms. Reflecting on the progress in other research fields, we are hopeful that in the area of hypnosis and suggestibility, if scientists begin to share data, we too can rapidly extend the knowledge that is currently available.

Changing the nature of the "state" versus "non-state" debate

As early as the French Royal Commission in the 18th century, chaired by Benjamin Franklin, investigators of hypnosis have been divided between those who view hypnosis in terms of psychological processes encountered in everyday life and those who view hypnosis as a rare or unusual processes outside the range of ordinary psychological functioning (Gauld 1992). Since the late 20th century this division has often been characterized as a debate between those who believe that responses to hypnotic suggestions (at least for highly susceptible individuals) involve or are facilitated by the individual being in an Altered State of Consciousness (ASC) (Kihlstrom 1997) and those that who explain hypnotic responses entirely in terms of more mundane, ubiquitous social, and cognitive processes that are not unique to hypnosis (imagery, focused attention, goal-directed cognitive strategies, response expectancies, etc.) (Lynn *et al.* 2008).

This division among experimenters is perhaps viewed as less of a divisive issue by clinicians, many of whom view hypnosis from both perspectives. For example, whereas most clinicians employ the vocabulary of hypnosis as an ASC (Christensen 2005), they are also keenly aware of the importance of their clients' perceptions of the situation and their interpersonal relationship in affecting the clients' readiness to respond to therapeutic suggestions.

Historically, the division in the "state" versus "non-state" perspectives was perceived as productive and generative of novel research, as researchers sought to formulate and test head to head hypotheses derived from state and nonstate theories. For example, many experiments evaluated or directly contrasted hypotheses derived from modern dissociation theories (Woody and Sadler 2016) or response expectancy theories (Lynn *et al.* 2008), respectively. However, when the evaluation of research – in particular neuroscientific research – is directed not at specific hypotheses, but at general "ideological" positions, progress quickly bogs down into unresolvable conceptual debates. This is not to dismiss the importance of conceptual debates in scientific progress, but only to recognize that some debates are fruitful and lead to a resolution of the issues, whereas engaging in unresolvable debates consumes intellectual resources that for the researcher might be better spent in other pursuits.

Moreover, once the scope of explanation is extended to include the emerging concepts and discoveries of human neuroscience, the distinction between state and nonstate explanations becomes difficult to sustain. For example, response expectancies (a putative nonstate mechanism of suggestion) are plausibly instantiated through predictive coding models of cortical functions. However, when implemented in such models, response expectancies engage with regulatory mechanisms that may result in the emergence of functionally distinct patterns of cortical dynamics (Jamieson 2016). Suppose this mechanism is shown to be involved in responses to hypnotic suggestions. Is this finding an example of a state or nonstate explanation? This will ultimately hinge on how an ASC is defined and consensus on such a definition remains elusive (Mazzoni *et al.* 2013).

Alternatively, suppose that functional connectivity (the exchange of information or coordination of activity) between the nodes of some cortical network (e.g. face recognition) is inhibited by some cortical mechanism in response to a suitable amnesia suggestion. This might be considered to instantiate dissociation, a putative ASC mechanism operating in hypnosis. However, selective cortical inhibition [topographically specific modulation of alpha band activity (Siegel *et al.* 2012)] is a mechanism widely regarded to regulate access to information of high-level cognitive processes. Therefore, this mechanism is ubiquitous in ordinary cognitive processes and might be considered a nonstate mechanism. In short, it is possible, even likely, that future discoveries regarding the neurophysiological basis of hypnosis can be interpreted in ways consistent with both models, as have virtually all of the discoveries made to date. A more productive path forward may be to focus on the integration of these seemingly competing accounts and the new lines of research suggested by such integration (Lynn and Green 2011).

The full range of differences on such interpretations was present in the Paris conference discussions. Some of us contend that the state debate may still prove to be theoretically valuable once other fundamental conceptual and theoretical issues are resolved. On the other hand, some of us maintain that continuation of this debate has been an unproductive distraction that hinges on superficial disagreements that lack theoretical substance and whose resolution will not yield a substantive advance in our understanding of hypnosis. In the absence of any means to reach consensus, it was agreed that continued insistence on the priority of the state versus nonstate issue would likely divert researchers from the common effort needed to resolve the important solvable questions now within technological reach, such as the neurophysiological correlates of hypnotic suggestibility, and the neural mechanisms that support responses to hypnotic suggestions. For example, how are individual differences in these effects expressed at the level of genetics, neurochemistry, structural organization, and propensity for specific forms of neural dynamics?

Consensus on the resolution of these fundamental questions is within the reach of current paradigms in the human neurosciences. Success in addressing these questions will be enhanced by collaborative efforts across laboratories that prioritize this research. Such a program is unlikely to proceed in a context dominated by individual research agendas committed to waging a divisive state versus nonstate conflict. Indeed, it is only once consensus has been achieved, on the core questions identified here, that a meaningful resolution of the state versus nonstate debate may become possible.

Summary and Conclusions

This article summarized the discussions held at a meeting of contemporary hypnosis researchers in the fall of 2015. The consensus view was that despite some barriers to hypnosis research, a great deal has been learned regarding the neurophysiological underpinnings of hypnosis in the past two decades. Highlights include clinical research supporting the efficacy of hypnosis for managing a number of clinical problems and symptoms, research supporting the role of various divisions in the anterior cingulate and prefrontal cortices in hypnotic

Table 1. Primary consensus recommendations for hypnosis research

1. Laboratory researchers should strongly consider how they assess hypnotic suggestibility in their studies, to help ensure that they are indeed studying hypnotic phenomena.
2. Researchers should strongly consider including participants who score in the middle range of hypnotic suggestibility in their studies.
3. Hypnosis researchers should also give thought to expanding the research designs used, when indicated and appropriate, to more properly dissociate the roles of inductions and specific suggestions.
4. The field would benefit from greater use of data-sharing, perhaps through the use of data registries.
5. The field would benefit from redirecting resources away from defending and attacking state or nonstate positions and toward research examining the neurophysiological underpinnings of hypnotic phenomena.

responding and that high hypnotic suggestibility is characterized by an atypical brain connectivity profile.

Five key recommendations for moving the field of hypnosis research forward were identified during the meeting (Table 1). First, there was consensus that while the assessment of hypnotic suggestibility may not be needed in clinical settings, and perhaps when conducting some clinical research, laboratory researchers should strongly consider the assessment of hypnotic suggestibility in their studies, to help ensure that they are indeed studying hypnotic phenomenon. Researchers should strongly consider including participants who score in the middle range of hypnotic suggestibility in their studies, given evidence that these individuals may differ in important qualitative ways from both highs and lows. Hypnosis researchers should also give thought to expanding their designs, when indicated and appropriate, to more properly dissociate the roles of inductions and specific suggestions. Finally, two specific suggestions for helping to move the field forward include (i) the use of data sharing, and (ii) redirecting resources away from contrasting state and nonstate positions toward research examining the neurophysiological underpinnings of hypnotic phenomena.

Findings from research on hypnosis have a great deal to offer the clinical and scientific community. As more is learned about the clinical applications of hypnosis treatments, the more individuals suffering from those conditions can be helped with hypnotic treatments – including most certainly chronic pain, irritable bowel syndrome, and PTSD, but also likely other conditions as well – can be helped. At the same time, as we learn more about the neurophysiological mechanisms underlying hypnosis and hypnotic phenomena, we will also learn more about basic brain functions and the responses influenced by hypnosis, such as amnesia, hallucinations, and delusions. We hope that this review article both inspires researchers to consider incorporating hypnosis into their research programs and also provides some guidance for the future direction of hypnosis research.

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