Neuroimaging Resolution of the Altered State Hypothesis

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Abstract

A controversy in the field of hypnosis has centered on the question of whether there is a uniquely hypnotic state of consciousness and, if so, whether it is causally related to responsiveness to suggestion. Evidence from brain imaging studies has been used to support claims for various altered state hypotheses, without resolving the debate. The designs of many neuroimaging studies confound the induction of hypnosis with the suggestions that can be given in or out of hypnosis, thus rendering them incapable of resolving the controversy. Brain imaging studies that do not have this confound support the hypothesis that hypnotic inductions produce changes in brain activity, but also indicate that these changes are not required for the experience of hypnotic suggestions or their neural correlates. The data remain equivocal as to whether there is a causal relation between the changes in brain activity produced by hypnotic inductions and those produced by other suggestions. It also remains uncertain whether the changes in activation produced by hypnotic inductions reflect a uniquely hypnotic state as opposed to more mundane processes.

Key words:

Hypnosis

Altered state

Suggestion

Default mode

1. Introduction

Some responses to hypnotic suggestion (e.g., analgesia, hallucinations, amnesia) seem so unusual that their reality has been called into question (e.g., Wagstaff, 1981). However, there is substantial evidence that hypnotized subjects can experience dramatic changes in experiences. Unlike people who have been instructed to fake hypnosis, highly suggestible[1] subjects continue to respond even when they believe they are alone (Perugini et al., 1998), and neuroimaging data are consistent with self-reported changes in experience (Kosslyn, Thompson, Costantini-Ferrando, Alpert, & Spiegel, 2000; Rainville, Duncan, Price, Carrier, & Bushnell, 1997). Even writers who have denied that there is a uniquely hypnotic state of consciousness have accepted that imaginative suggestions can alter experience in susceptible subjects (Kirsch, 1998; Kirsch & Lynn, 1995; Lynn, Kirsch, Knox, Fassler, & Lilienfeld, 2007).

Although the ability of suggestion to alter experience is undoubtable, the role of a hypnotic state (a.k.a., trance) in this process has been a focus of controversy. For over half a century, it has been questioned whether hypnosis can be regarded as an altered state of consciousness (Kirsch & Lynn, 1995). The issue is generally portrayed as a dichotomy, but it is better conceived as involving fuzzy points on a continuum, with differences between adjacent points sometimes being very subtle. There are at least five well-articulated views on the issue (Kirsch, 2011), which can be delineated as follows:

1. The Qualitative State Hypothesis (James, 1890; Kallio & Revonsuo, 2003; Kosslyn, et al., 2000). This is the traditional received view of hypnosis, according to which the subjective alterations produced by suggestion in responsive subjects require the presence of an alteration in background state of consciousness, commonly referred to as a "trance." Easy suggestions (for example, simple ideomotor responses, which most people can experience) require only a light trance, whereas more difficult responses (e.g., hallucinations) require a very deep trance state, which can be achieved by only a small percentage of people.

2. The Quantitative State Hypothesis (Hilgard, 1975; Hull, Patten, & Switzer, 1933). The quantitative state hypothesis was prompted by the consistent finding that people can respond to the suggestions usually given in hypnosis even without the induction of hypnosis (reviewed in Kirsch, Mazzoni, & Montgomery, 2007). This research showed that hypnotic inductions increased responsiveness to a relatively small degree, but were not a necessary precursor for successful responding to any particular suggestion. Thus, although proponents of the quantitative state hypothesis agree that hypnotic inductions produce an altered state of consciousness in susceptible subjects, they do not view that state as necessary for the experience of suggestions. Instead, they see the effects of the state as quantitative, in that they merely enhance responsiveness to suggestion to a relatively small degree. As framed by Hilgard (1975, p. 21), the question is "does hypnotic induction (presumably producing "state" according to state theorists) succeed any better than nonhypnotic manipulations in producing hypnotic-like responses?" The answer to this question, as summarized by Hull (1933), is that "no phenomenon whatever can be produced in hypnosis that cannot be produced to lesser degrees by suggestions given in the normal waking condition" (p. 391).
3. The Non-State Hypothesis (Barber, 1969; Sarbin & Coe, 1972). Contrary to common misconceptions, non-state theorists did not deny that suggestion can produce alterations in experience in suggestible subjects. However, they rejected the idea that hypnotic state is needed to explain people's abilities to respond to hypnotic suggestions. Instead, these are brought about by the motivation to experience suggested phenomena, the expectancy that one can do so, personal characteristics of the responsive subject (e.g., fantasy proneness; Lynn & Rhue, 1988), acceptance of the role of the hypnotic subject, and the various psychological constructs that that are not specific to hypnosis, but are used in understanding cognition and behavior more generally.

4. The Weak State View. According to the "weak version of the state view," which Kihlstrom (Kihlstrom, 1985) ascribes to Hilgard (1969), the term *hypnotic state* "serves only as a label representing some domain of characteristic phenomena, including suggested behaviors and self-reports of experience…a kind of shorthand, with no causal properties or defining features associated with it (Kihlstrom, 1985, p.405)." Nominally, this is an altered state view of hypnosis, but as Kihlstrom notes, there is no substantive difference between this and non-state hypotheses.
5. The Epiphenomenal Hypothesis (Wagstaff, 1998, 2000). The epiphenomenal hypothesis is a relatively recent variant of the non-state approach. Hypnotic inductions can be regarded as a particular type of suggestion. Regardless of whether it is based on relaxation, imagery, alertness, focused attention, etc., it is suggested that the subject is entering an altered state of awareness. The alterations in the participants' reported experiences following the induction of hypnosis may, at least in part, be due to the suggestion that they are entering hypnosis, coupled of course with whatever they believe hypnosis to be. From this perspective, inductions produce changes in subjective experience and also in the neural correlates of those changes (Lynn, et al., 2007). However, these changes in experience and their underlying neural substrate are epiphenomenal, in the sense that they do not affect responsiveness to other suggestions or performance on any other task for that matter. They are merely a response to one particular suggestion (i.e., the suggestion to feel hypnotized) among others.

More than a half century of behavioral research on the altered state issue resulted in a stalemate. The development of neuroimaging techniques has provided a new means of testing the altered state hypothesis, but it has not resolved it. The focus of this review is to examine neuroimaging studies that address the altered state issue in hypnosis.

2. Research Designs

Despite a relatively large number of neuroimaging studies of hypnosis (reviewed in Oakley and Halligan, 2010), the stalemate over the altered state issue remains intact. A major impediment to resolution of the altered state debate by brain imaging data has been the use of research designs that confound the two principal components of hypnosis: the induction of the hypothesized hypnotic state and the provision of suggestions while in hypnosis. In many studies, hypnosis is induced and a hypnotic suggestion then given (e.g., automatic movements, movement inhibition, perceptual alterations, and the like). This condition is then contrasted to one in which both the induction and the suggestion are omitted. This is a perfectly fine design that allows us to establish whether hypnotic suggestions (i.e., suggestions given during hypnosis) can produce a particular effect on the experience or performance of the task. Studies using this design have shown changes in brain activation accompanying responses to suggestions for analgesia (Hofbauer, Rainville, Duncan, & Bushnell, 2001; Rainville, et al., 1997), word reading (Raz, Fan, & Posner, 2005), suggested paralyses (Halligan, Athwal, Oakley, & Frackowiak, 2000), and phantom limb sensations (Ersland et al., 1996; Willoch et al., 2000). However the effects obtained in this design can easily be misinterpreted as due to hypnosis, a misinterpretation that violates one of the basic axioms of research in hypnosis. As stated by Sheehan and Perry (1976) "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" (p. 55). To examine the effects of hypnosis per se, one needs to use experimental designs that disentangle the induction of hypnosis from the effects of suggestions given when in hypnosis.

Oakley and Halligan (2010) have provided a useful guide to research design, in which they consider the types of design needed in neuropsychological research in order to answer various questions about hypnosis. In particular, they draw attention to the "most basic experimental design needed to address the effects of a hypnotic induction procedure ('trance') *per se* and /or those of suggestion, including the relationship between them (p. 83)." This is a 2 x 2 design in which hypnosis

either is or is not induced and a suggestion is or is not given (see figure 1). As noted by Oakley and Halligan (2010), it is essential that the wording of the suggestion in groups C and D (suggestion in and out of hypnosis) are identical.

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. In other words, it can test whether differences found between conditions B and D can also be found between conditions A and C. This difference is predicted by all theoretical stances except the qualitative state view. A related question is whether the induction of hypnosis enhances the effects of suggestion, as predicted by both the quantitative state hypothesis and the non-state hypothesis, but not the epiphenomenal hypothesis. In other words, is there an interaction such that the differences between conditions B and D (suggestion vs no suggestion in hypnosis) are significantly greater than those between A and C (suggestion vs no suggestion out of hypnosis)?

Surprisingly, no study seems to have adopted the basic 2x2 design. Although the need to disentangle suggestion and induction was identified as early as the 1930s (Hull, 1933; Hull & Huse, 1930), researchers have shown great reluctance towards adopting the full basic design. This may be linked to the concern that in the condition in which participants receive the suggestion without any hypnotic induction, highly suggestible individuals might unintentionally slip into a 'trance' state (Hilgard & Tart, 1966; Kosslyn, et al., 2000), which would obscure the possibility of detecting specific patterns of brain activation exclusively attributable to the hypnotic induction per se. However, the idea that people can slip into a trance state assumes the existence of a trance state, which is the very issue that many of these studies aimed at elucidating. This stance has certainly delayed the possibility of finding clear markers of a hypnotic state, that necessarily require understanding whether hypnosis per se has an effect on brain activity, without any contribution of the suggestion. In any case, the basic design described by Oakley and Halligan (2010) allows researchers to assess this possibility. If highly suggestible hypnotic subjects slip into trance even without the inductions,

then conditions B, C, and D should show some brain activation differences from condition A, because the former three groups would be in a hypnotic trance and the latter group would not.

The minimal criterion for evaluating the effects of inducing hypnosis is the inclusion of at least two conditions in which all the variables are held constant except the presence versus absence of a hypnotic induction. There are two simplifications of Oakley and Halligan's (2010) basic design that meet this criterion. One of these compares neutral hypnosis to the normal waking state (conditions A versus B); the second compares the effects of a suggestion given in hypnosis to those of the exact same suggestion given without it (conditions C versus D). We will refer to these as 'minimal designs.' We have identified five minimal design neuroimaging studies comparing neutral hypnosis to no hypnosis (Crawford, Gur, Skolnick, Gur, & Benson, 1993; Egner, Jamieson, & Gruzelier, 2005; Deeley et al. as described in Oakley & Halligan, 2010; Rainville, Carrier, Hofbauer, Bushnell, & Duncan, 1999; Rainville, Hofbauer, Bushnell, Duncan, & Price, 2002) and none assessing brain responses to a suggestion with hypnosis versus without hypnosis, when the identically worded suggestions are given in the two conditions.

There is an important element missing from the basic design. Most brain imaging studies of hypnosis have included only high suggestible subjects. The exclusion of low suggestible participants creates an interpretive problem. Suppose one finds an alteration in brain activity following the induction of hypnosis. It would be tempting to interpret this as a brain marker of hypnosis. Hypnotic inductions, however, contain a number of components. For example, most hypnotic inductions contain instructions for relaxation. In fact, merely adding the word 'hypnosis' to a relaxation training procedure turns that procedure into a perfectly adequate hypnotic induction.

One way around this problem is to include low suggestible (a.k.a. low hypnotizable) participants in the research design. This allows separation of the effects due to the presence of a hypnotic state from those produced by other aspects of the hypnotic induction. Thus the expanded design becomes a 2x2x2 (hypnosis by suggestion by suggestibility) design (Figure 2).

This design is better than the basic design in addressing the question of whether hypnotic inductions produce a particular altered state of consciousness. If they do, then activation differences should be observable between conditions A and B, but not between conditions E and F. In other words, the induction should produce differences in brain activity only in suggestible participants (i.e., those who are considered 'susceptible' to hypnosis). This would be the prediction of both qualitative and quantitative state hypotheses, and it would also be predicted by the epiphenomenal view. The traditional non-state hypothesis also allows that the induction of hypnosis could produce physiological alterations. These would be the psychophysiological substrate of the alterations in motivation, expectancy, and other mundane psychological factors, rather than a trance state.

3. Research Using the Minimal, Basic, or Expanded Designs

3.1. Studies Using Minimal Designs

Of the five studies that aim at unveiling the brain markers of a hypnotic state and meet the minimal criteria for detecting brain markers related to a hypnotic state (Oakely & Halligan, 2010), four compared brain activation in and out of hypnosis while participants are engaged in concomitant tasks, such as keeping their hand immersed in water of varying temperature (Rainville, et al., 1999; Rainville, et al., 2002), performing the Stroop task (Egner et al, 2005), or monitor a flashing checkerboard display (Deeley et al. as described in Oakley & Halligan 2010). Both Rainville et al (1999) and Rainville et al (2002) compared a pre-hypnosis baseline with a hypnosis condition while having participants keeping their left hand in water of various temperatures. The hypnosis condition showed greater activation in occipital regions and part of the right anterior cingulate cortex, and decreased activity in posterior parietal areas.

Egner et al. (2005) compared brain activation in and out of hypnosis while participants were engaged in a Stroop task, but without any suggestions related to the task. The aim was to examine

the effect of a hypnotic induction on conflict monitoring. Unlike most brain imaging studies of hypnosis, both high and low suggestible individuals were examined in and out of hypnosis. Also, an alert induction, in which there were no instructions for relaxation, was used, thereby precluding effects that might have be due to simple non-hypnotic relaxation. In this well designed study, however, the presence of an active task might have hindered the possibility of observing patterns of brain activation that are exclusively related to a hypnotic state. The difference in activation associated with hypnosis seems to be related more to the task at hand, than to hypnosis per se, as the observed increased activity in the anterior cingulate cortex when in hypnosis reflects cognitive conflict. This is true even if, when comparing high and low suggestible individuals, Egner et al found that hypnosis increased activation in ACC during the Stroop task only in the high suggestible group.

In a recent unpublished study on neutral hypnosis (Deeley et al. as described in Oakley & Halligan 2010), participants were asked to monitor a flashing checkerboard display both in and out of hypnosis. The hypnotic induction included relaxation and dream-like imagery, and a self-report scale was used to measure depth of the hypnotic state. While depth correlated positively with increased activity in brain regions involved in working memory and the maintenance of attention, it correlated negatively with activity in areas (left medial frontal gyrus, bilateral parahippocampal gyri and left posterior cingulate gyrus) involved in the default mode of the brain (Gusnard & Raichle, 2001; Mason et al., 2007). The default mode network refers to those areas of the brain that are activated when people are not engaged in any specific cognitive task, but rather are letting their minds wander at rest.

An early brain imaging study by Crawford *et al* (1993) aimed at examining directly the brain activation characterizing a hypnotic induction. In one condition they compared brain activity in a resting state when high and low suggestible participants were in and out of hypnosis, and observed that in hypnosis participants showed a greater overall cortical activation. This result was interpreted as showing that 'hypnosis requires cognitive effort'. In other words, when in hypnosis, people activate their supervisory attentional control system even when they are in a resting state (i.e., not

responding to any suggestion other than the suggestion to be in hypnosis, and not engaging in any other specified task). These results are interesting not only because they underline the difference between a potential hypnotic state, but also as they imply that highly suggestible participants seem to be more engaged after a hypnotic induction, compared to when they are they have not been hypnotized.

3.2. Studies Using the Expanded Design

To date, only one brain imaging study using the expanded design has been reported. Our research (McGeown, Mazzoni, Venneri, & Kirsch, 2009; McGeown et al., 2012) on hypnosis and suggested color hallucinations was based on an earlier study aimed at investigating changes in brain activity as a function of hypnosis and suggestion (Kosslyn, et al., 2000). Kosslyn et al. (2000) reported that suggestions given in hypnosis to perceive color in a grey-scale stimulus and to drain color from a colored stimulus altered brain activity bilaterally in the extrastriate visual cortex of highly suggestible subjects. They also reported that these changes in activation were limited to the right hemisphere when the participants were asked to imagine changes in color without the induction of hypnosis. The authors interpreted their results as indicating that suggestion related perceptual changes require the induction of a hypnotic state. However, this study confounded the induction of hypnosis with the wording of the suggestions for altered perception. The problem in the design is clearly revealed in figure 3. In hypnosis there was a suggestion that they would 'see' the colors as different from what they really were, but in the no-hypnosis condition participants were instead asked to 'remember and visualize' the differences in color.

The difference in wording was prompted by the concern that the suggestion as worded in the hypnosis condition might prompt subjects to slip into a hypnotic state, even without a hypnotic induction. The problem with this means of preventing slipping into trance is that the experimental design confounds hypnosis and suggestion, making it impossible to know whether obtained differences in brain activation were due to the induction of hypnosis (as the authors suggested) or to

the difference in wording used to elicit the reported changes in color perception. Differences in the wording of hypnotic suggestions are crucial, as there is a clear difference in brain activation depending on whether a hypnotized participant is given a suggestion to experience, or asked to imagine a subjective change (e.g. Derbyshire et al 2004 [pain]; Szechtman et al 1998 [auditory hallucination]).

3.2.1 Behavioral Results

As a first step in our research, we conducted a multi-site behavioral study, conducted in three countries (Italy, Portugal, and the United Kingdom), using the expanded design described above (Mazzoni et al., 2009). The participants were 30 highly suggestible and 8 low suggestible individuals drawn from a pool of 263 students who had been screened on standard scales of hypnotic suggestibility. After being greeted by the experimenter, they were told:

> *Previous research has shown that some people with very high levels of imaginative ability are able to see a color stimulus as grey and a grey stimulus as colored. Research has also shown that people can respond to suggestions for perceptual alterations whether or not they have been hypnotized. The purpose of this study is to assess your ability--both in and out of hypnosis--to experience colored stimuli as if they were grey and grey stimuli as if they were colored.*

They were then shown the two stimuli displayed in Figure 4 so that they would understand the nature of the color changing task.

On each of four trials, two of which were preceded by a hypnotic induction consisting of suggestions for relaxation, pleasant visual imagery, and entry into a hypnotic state, participants were asked to first see the stimulus as it actually was (in color or in shades of grey). Following a pause of ten seconds, they were asked to alter their perception of the stimulus. When shown the grey-scale pattern, the suggestion was to alter their perception by adding color, so that they actually saw the pattern in full color. When shown the colored pattern, the suggestion was to drain color so that they only saw shades of grey. Hypnotic and non-hypnotic trials were counterbalanced.

At the conclusion of the session, participants were asked to indicate their states of consciousness during the hypnosis trials and during the no-hypnosis trials. As shown in figure 5, reports of being in hypnosis were confined to high suggestible participants and only during the hypnosis part of the session. There was no evidence of any subject slipping into trance. Nevertheless, as shown in figure 6, high suggestible participants reported being able to change their perception of the pattern from gray scale to color and vice versa, regardless of whether they had been hypnotized.

3.2.2 fMRI Results

British and Italian highly suggestible participants who had shown to be able to add and drain colour were subsequently invited to participate in the brain imaging study, as were low suggestible Italian participants. The fMRI task followed a block design. During the time of scanning each participant experienced a rest period (20 seconds) followed by the passive viewing of a greyscale Mondrian-like pattern (30 seconds), the same greyscale pattern with the suggestion to add color (30 seconds), a period in which they had to rate the intensity of the color that they had seen during the add condition (14 seconds), another rest period (20 seconds) followed by the passive viewing of a full color Mondrian-like pattern (30 seconds), the same color pattern with the suggestion to drain the color (30 seconds), and a period in which they had to rate how much color they saw during the drain condition (14 seconds). Each of these conditions was repeated four times in each run and the color and greyscale trials were counterbalanced within and across runs. There were 4 runs in total (2 which were subsequent to a hypnotic induction, 2 in the absence of a hypnotic induction). The hypnosis/no hypnosis conditions were counterbalanced across participants with half being imaged under hypnosis first and the other half out of hypnosis first, to ensure that any potential effect of order (participant or scanner related) would not affect the findings.

The rest periods in this study comprise conditions of “neutral hypnosis” and the “alert waking state,” thus allowing us to establish whether the hypnotic induction in itself produced alterations in

brain activity that could be interpreted as indicating the presence of a hypnotic state. As shown in Figure 7, in neutral hypnosis high suggestible participants showed decreased brain activity in the anterior parts of the default mode circuit, compared to when they had not been hypnotized. In low suggestible people, hypnotic induction produced no detectable changes in these regions, but instead deactivated areas involved in alertness (thalamus, caudate nucleus and insula, bilaterally, and right subthalamic nucleus). These findings indicate that hypnotic induction creates a distinctive and unique pattern of brain activation in highly suggestible subjects that is different from those observed in low suggestible people. These data are consistent with all theoretical positions on the altered state issue (see Lynn, et al., 2007). The question that remains to be determined is whether the changes in the anterior default mode deactivation are due to mundane psychological variables like enhanced attention, motivation, or expectancy, or whether they reflect more fundamental alterations in cognitive functioning, as hypothesized by traditional altered state theorists. As noted by Charles T. Tart (1983, p. 19), the concept of an altered state of consciousness involves “major alterations in both the content and pattern of functioning of consciousness. The major pattern connoted by 'state' should not be trivialized by using the word 'state' to refer to any change in condition.”

An analysis of variance (ANOVA) on changes in brain activity associated with the suggestion to hallucinate color in a grayscale pattern showed a main effect of suggestibility, with high suggestible participants showing significantly higher activation in a number of visual areas including the left middle occipital gyrus, the right lingual gyrus, and the fusiform gyrus, bilaterally. There was also a main effect of hypnosis, with significantly higher activation in hypnosis observed in the right cuneus and in the lingual gyrus, bilaterally. The significant group by condition interaction that would be predicted by altered state hypotheses was present only in the right lingual gyrus, and the middle occipital gyrus and cuneus, bilaterally.

The effects of the color hallucination suggestion on brain activity is shown in figure 8. The crosshairs in this figure are centered on the left fusiform region. This region is particularly

important, as it formed the basis of Kosslyn et al.'s (2000) claim that the induction of a hypnotic state was a necessary prerequisite for hallucinating color. Although they found significant increases in activation in the right fusiform region regardless of whether participants were given the suggestion to see color in hypnosis or asked to imagine it outside of hypnosis, left fusiform activation was only present in the hypnotic suggestion condition. In contrast, we found left fusiform activation when highly suggestible participants were asked to hallucinate color both in and out of hypnosis (figure 9). However, the induction of hypnosis produced a significant difference in activity in the cuneus bilaterally during the color hallucination suggestion, which is consistent with the behavioral results of this study, in which participants reported that a small but significant enhancement of their ability to alter color perception in hypnosis.

Having found reductions in activity in areas that are part of the anterior default mode network in high suggestible individuals during neutral hypnosis, we wondered whether there might be a relationship between these alterations in brain activity and the modulation of activity produced by hypnosis when subjects were asked to hallucinate color. To test this hypothesis, a correlation analysis was carried out between differences in activity during rest while in and out of hypnosis and the activity difference in and out of hypnosis when participants were responding to the color adding suggestion. Voxels showing significant correlations were found in the right middle occipital gyrus, and bilaterally in the cuneus and lingual gyrus (see Figure 10a and b). Thus, the greater the level of deactivation of the default mode in neutral hypnosis, the greater the level of activation in these visual areas during the color adding suggestion in hypnosis.

4. Conclusions

Has neuroimaging research resolved the altered state debate? For the moment the answer is negative, but the data acquired have narrowed down the terms of the debate. The data reported by McGeown et al. (2012) combined with a wealth of behavioral data (reviewed in Kirsch, et al., 2007) seem to converge in ruling out the qualitative state hypothesis, according to which suggested

perceptual alterations and the corresponding brain activity cannot occur unless the subject is in a hypnotic trance. The behavioral evidence is clear and confirms that in high suggestible individuals even the most difficult hypnotic suggestions can be experienced without the induction of hypnosis. There are also data showing that high suggestible participants do not fall into a trance state when responding to suggestions without the induction of hypnosis (Mazzoni, et al., 2009). Nevertheless, they do experience the suggested effects, as evidenced by their self reports and their observed behavior. The behavioral evidence is supported by the observation of concomitant changes in brain activity in regions associated with the suggested change in experience.

The data also indicate specific changes in brain activity when highly suggestible individuals experience a hypnotic induction. The brain activation changes are not necessary for the subjective experience of suggested alterations of perception, but they are associated with the degree to which these perceptual alterations occur. Although these data are inconsistent with the qualitative state view, they are consistent with all remaining theoretical positions. They are consistent with the quantitative state hypothesis, which holds that the function of the hypnotic state is to enhance responsiveness to suggestions that can also be experienced, albeit to a lesser degree, without it. They are also consistent with the epiphenomenal non-state hypothesis, according to which the hypnotic state is not causally related to the experience of hypnotic suggestion. They can be accommodated by the traditional non-state view, because we cannot rule out the possibility that the observed reduction in default mode activity may be due to enhanced motivation, expectancy, and/or active attention to the task of being a hypnotized subject. As noted by McGeown et al. (2012, p. 115), “the hypnotic induction may lead highly suggestible participants to focus attention on the anticipated suggestions, thereby allowing them to make better use of their imaginative skills.”

Although the current data are not inconsistent with traditional non-state theories, they might be explained more parsimoniously by the epiphenomenal and quantitative state hypotheses. Inductions, which can be interpreted as suggestions to enter a hypnotic state (Wagstaff, 1998), result in decreases in activity in anterior default mode areas (McGeown, et al., 2009) and greater

overall cortical activation (Crawford, et al, 1993) in responsive persons. Our data reveal that these decreases in default mode activity are correlated with increases in brain activity in areas associated with subsequent responses to color hallucination suggestions. The question remains whether there is a causal relation between these two correlated changes in brain activity. The correlation between state changes and suggestion-related changes in brain activity can be interpreted either way. Responses to different hypnotic suggestions are correlated with each other, but that does not mean that there is any causal relation between one suggestion and another. It seems unlikely, for example, to suppose that responding to an arm levitation suggestion either causes or is caused by responding to a motor inhibition suggestion, despite the fact that the two are generally correlated (hence the internal consistency of suggestibility scales).

More important to this issue is the nature of the changes in brain activity that have been found when neutral hypnosis has been compared to the alert waking state in high suggestibles. Crawford et al. (1993) found general cortical activation and more recent published (McGeown et al, 2009 and unpublished (Deeley et al, 2008, as described in Oakley and Halligan, 2010) research has reported decreased anterior default mode activity in neutral hypnosis. The default mode is associated with passive mind wandering and self-reflective thought during rest periods between tasks (Mason, et al., 2007). Reductions in default mode activity occur when people actively attend to a cognitive task and are usually associated with task related increases in task-related regions. We (McGeown, et al., 2009) did not find any particular regions of significant increase, but the decrease seems at least consistent with Crawford et al.'s report of increased cortical activity overall. Taken together, these findings lend support to the hypothesis that high suggestible people approach hypnosis as an active task that requires their attention, whereas low suggestible people interpret it as a phenomenon that just happens to them and simply wait passively for it to happen (Spanos & Chaves, 1989). Thus, hypnosis might be best conceived as a state of preparedness, a preparatory set in which attention is focused on the anticipated upcoming suggestions, rather than a fundamental shift in the functioning of consciousness.

Our conclusions remain tentative, as the number of studies on which they are based remains small. At the very least, replication is needed. In future brain imaging studies it would also be important to study different hypnotic inductions (e.g., relaxation inductions and alert inductions), as well as the importance of identifying the procedure as "hypnosis" to the participants. Future studies should also include moderately suggestible participants, as well as high and low suggestible individuals. After all, the bulk of the population is moderately suggestible, and it would be important to know whether their brain responses following inductions and suggestions are like those of low suggestibles, high suggestibles, or somewhere in between.

Finally, we note that the inability of the neurophysiological data to distinguish between non-qualitative state views and the traditional and epiphenomenal non-state views parallels a similar impasse in when state and non-state views were debated on the basis of behavioral data. The problem may be in the subtleties of the distinctions between these points of view. Compare, for example, Hilgard's (1986) explanation of why (from an altered state perspective) hypnotic inductions might enhance responsiveness to suggestion with that of Barber, Spanos, and Chaves (1975), writing from a non-state perspective.

Hilgard (1986):

> After a subject has agreed to participate in hypnosis and has been hypnotized according to any of the several methods, he perceives that some changes have taken place, partly as a response to the suggestions that have been given in the induction, such as relaxation of his muscles, drowsiness, and other subtle changes that are part of the total experience for him…This feeling of being hypnotized, being in some kind of changed condition or state, makes him ready to accept the suggestions of the hypnotist to produce the specific responses that are called for. (p. 163)

Barber, Spanos, and Chaves (1975):

> If a subject responds to the relaxation-sleep-hypnosis suggestions or to some of the other variables involved in induction procedures, and, consequently, experiences changes in body feelings and judges from his responses that he is hypnotized, his expectancy that he can be affected by suggestions is enhanced. His enhanced expectancy, in turn, tends to heighten his responsiveness to subsequent test suggestions. (p.45)

The position contained in the above quotations can also be found in Kirsch's (Kirsch, 1985, 1991) response expectancy theory, according to which the compelling changes in experience produced by primary or imaginative suggestions in or out of hypnosis are seen as partly due to the expectancy of their occurrence. In words that seem a paraphrase of the quotations from Hilgard (1986) and Barber et al. (1976), Kirsch (1991) wrote:

> The initial experience of a hypnotic induction is likely to alter one's expectancies for responding to suggestions. Subjects who experience greater changes in conscious state (feelings of relaxation, numbness, heaviness, etc.) are likely to have heightened expectancies, whereas those experiencing less change are likely to have lowered expectations...The sine qua non of an effective hypnotic induction is the subject's belief in its effectiveness. It follows that hypnotic inductions can best be understood as expectancy modification procedures. (p. ?)

These quotations reveal a common understanding between a presumed state theorist and presumed non-state theorists on how inductions produce changes in experience that then influence the degree to which subjects respond to suggestion. There is no altered state issue to resolve between these two positions. The only altered state issue of substance is that of whether a trance state is a necessary prerequisite for the experience of hypnotic suggestions, which is the traditional, received, altered state hypothesis, and on this point the most recent neuroimaging data are clear. Neither the induction of hypnosis nor the cortical alterations it produces in responsive subjects are

necessary prerequisites for the experience of hypnotic suggestions, as revealed by self-report and suggestion-related changes in brain activity.

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Footnotes

[1]There are various types of suggestion and hence various types of suggestibility. In this article, we use the term suggestibility to refer to responsiveness to the kinds of suggestion usually given in hypnosis (e.g., automatic movements, movement inhibition, and perceptual alterations), which have variously been termed primary or imaginative suggestibility (Braffman & Kirsch, 1999; Eysenck & Furneaux, 1945)

Figure Captions

Figure 1. The basic experimental design for disentangling the effects of hypnosis and suggestion (adapted from Oakley and Halligan, 2010). The term 'neutral hypnosis' has been used historically to designate a condition in which hypnosis is induced but no further suggestions are given. The term 'waking' has been used to designate suggestions that have not been preceded by a hypnotic induction. Note however, hypnotic inductions do not induce sleep. Hence the term is a misnomer.

Figure 2. An expanded experimental design including high and low suggestible participants.

Figure 3. The design of the Kosslyn et al (2000) (Adapted from Oakley and Halligan, 2010).

Figure 4. Colored and grey-scale patterns used for color perception suggestions. The suggestions were to drain color from the pattern on the left and add color to the pattern on the right.

Figure 5. Hypnotic state reports in high and low suggestible participants, with and without the induction of hypnosis (reprinted from Mazzoni et al., 2009). Scores ranged from 0-3, with 0 representing a "normal wide awake state" and 3 representing "deeply hypnotized."

Figure 6. Responses to color changing suggestions in high and low suggestible individuals, with and without the induction of hypnosis (reprinted from Mazzoni et al., 2009). Following each trial, participants were asked to indicate how much color they saw in the stimulus (from 0 to 100%) after the suggestion to alter their perception of it. These scores were then transformed into indications of responsiveness to suggestions for color alteration. This was done by dividing each score by 100 and, for the color draining suggestion, subtracting the result from 1. Then the mean of these two scores was calculated for each participant. Thus, 0 represented no success at adding or draining color, and 1 represented complete success on both tasks.

Figure 7. Areas of decreased activation due to hypnotic induction in the resting state in high suggestible participants (blue) and low suggestible participants (red). Significant between group differences (greater deactivation in the highs than in lows when directly compared) are shown in yellow (reprinted from McGeown et al, 2009)

Figure 8: Random effects analyses showing a) the pattern of activation when viewing color was compared to viewing grey, and the activated regions when adding color to the grey pattern was compared to viewing a grey pattern for b) the high suggestible people without the hypnotic induction, c) the high suggestible people with the hypnotic induction, d) the low suggestible people without the hypnotic induction, and e) the low suggestible people with the hypnotic induction. Regions in yellow represent activation cluster corrected, whereas activation in red represents activation not surviving this correction. While performing the color adding task, activation can be seen in the high suggestible people in the fusiform and lingual gyri, bilaterally, with or without the hypnotic induction. Activation is absent in these regions in the low suggestible people both with and without the hypnotic induction. Crosshairs are centred on the left fusiform region (Talairach co-ordinates -26, -68, -8), Brodmann's area 19 (part of V4) (reprinted from McGeown et al, 2009).

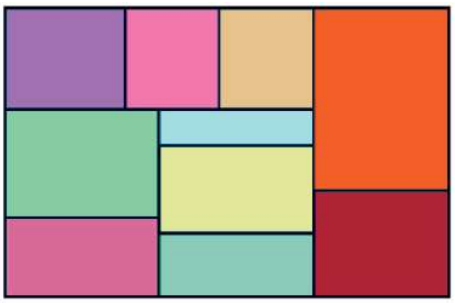
Figure 9. Changes in activation in the left fusiform gyrus (ROI analysis centred on the voxel corresponding to Talairach co-ordinates [-26,-68, -8]) when participants attempted to hallucinate color while looking at the grey image.

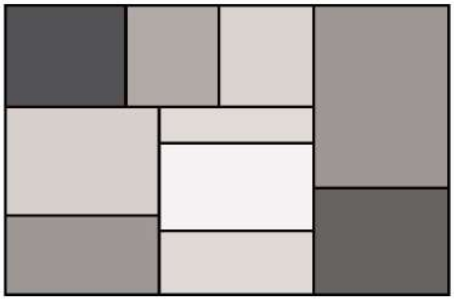
Figure 10: a) The correlation between lower activity in the default mode network during rest (when hypnosis is compared with no hypnosis) and the activity on the task to hallucinate color (hypnosis versus no hypnosis). b) Plot of the correlation taken from the peak voxel in the left lingual gyrus (reprinted from McGeown et al, 2009).

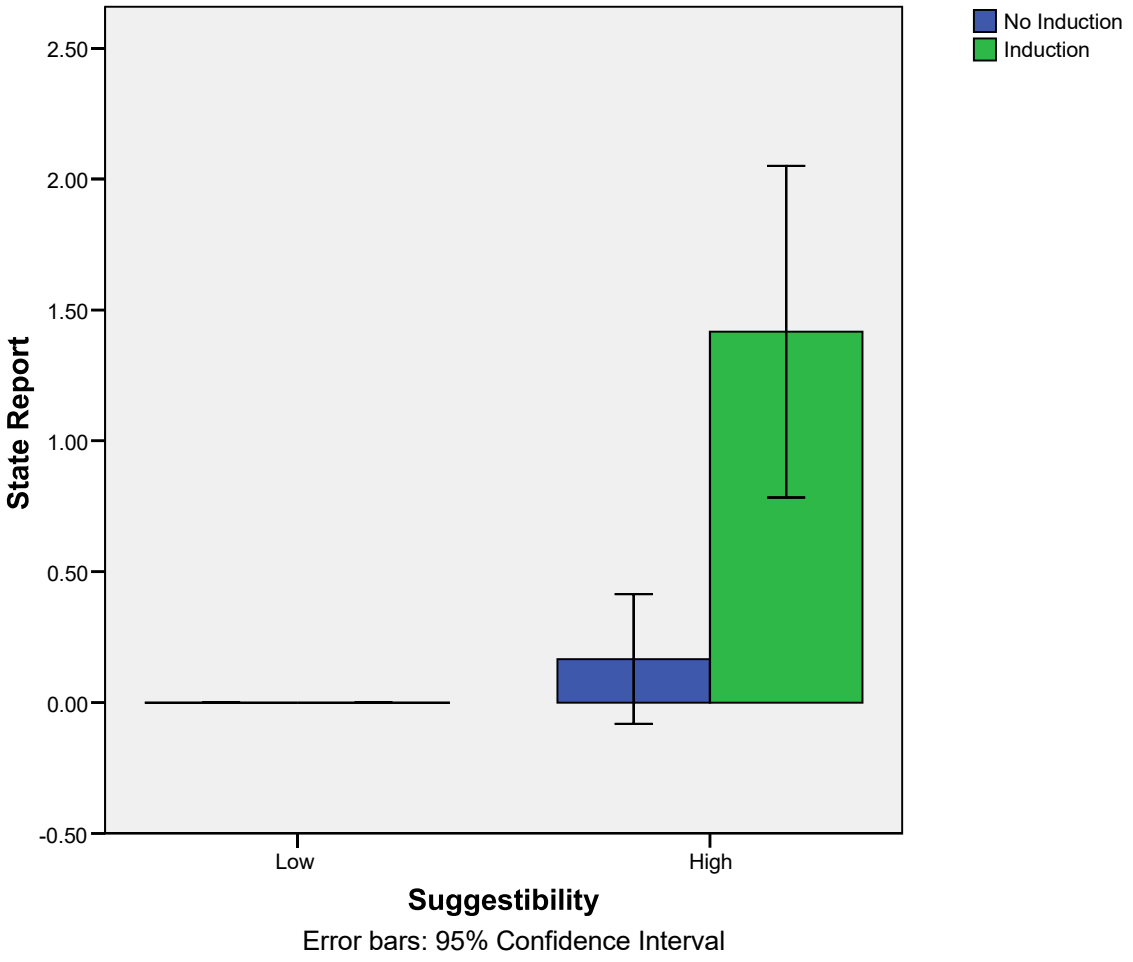
	No 'hypnosis'	'Hypnosis
No suggestion	**A** 'Normal' alert state	**B** 'Neutral' hypnosis
Suggestion	**C** 'Waking' suggestion	**D** 'Hypnotic' suggestion

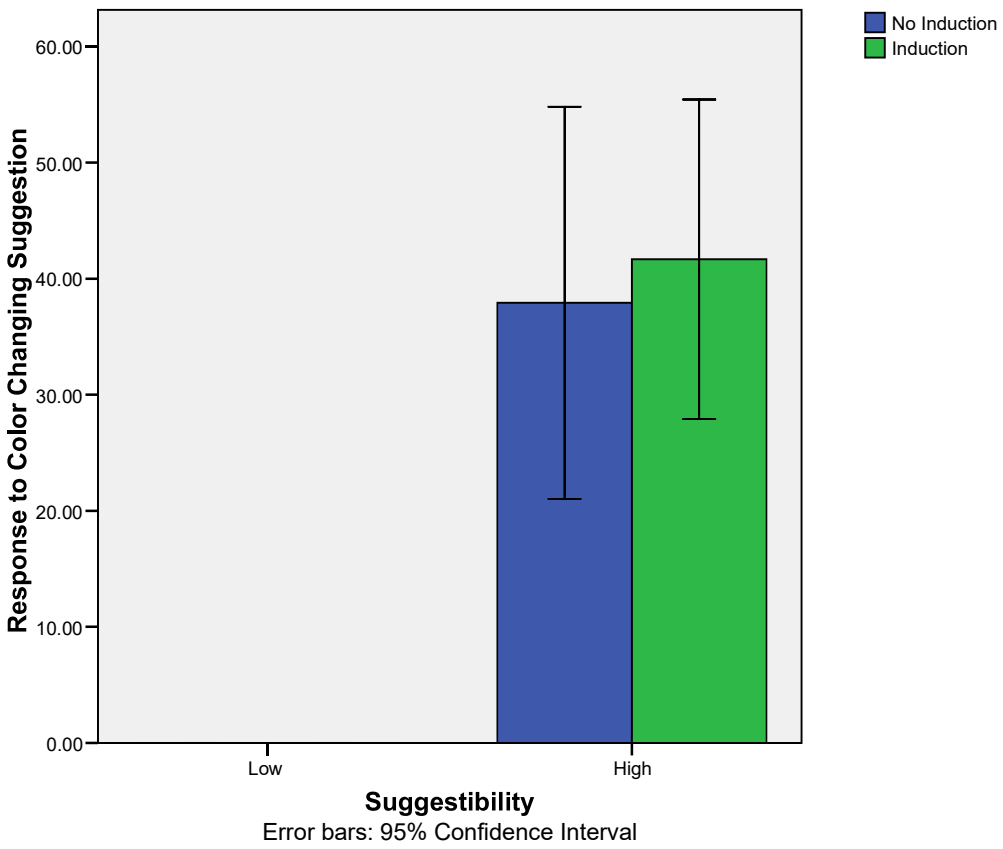
		No 'hypnosis'	'Hypnosis
High suggestible	No suggestion	**A** 'Normal' alert state	**B** 'Neutral' hypnosis
	suggestion	**C** 'Waking' suggestion	**D** 'Hypnotic' suggestion
Low suggestible	No Suggestion	**E** 'Normal' alert state	**F** 'Neutral' hypnosis
	Suggestion	**G** 'Waking' suggestion	**H** 'Hypnotic' suggestion

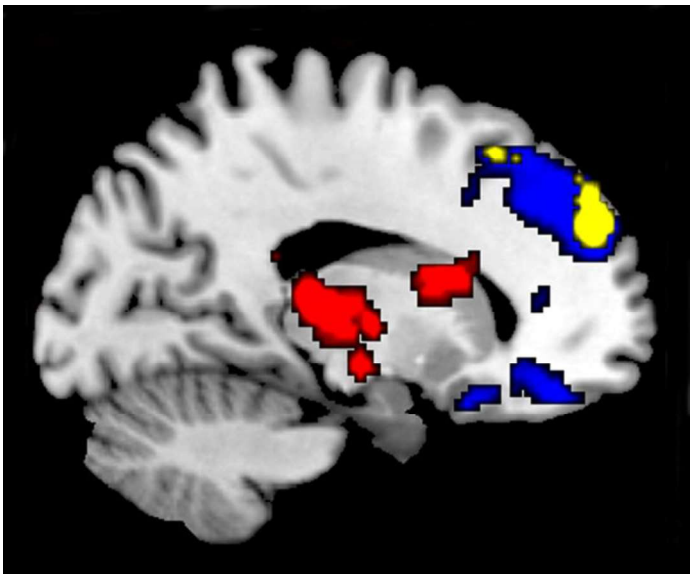
	No 'hypnosis	'Hypnosis'
Suggestion	**A**	**B** 'Hallucinate color'
Imagination	**C** 'Remember and visualise color'	**D**

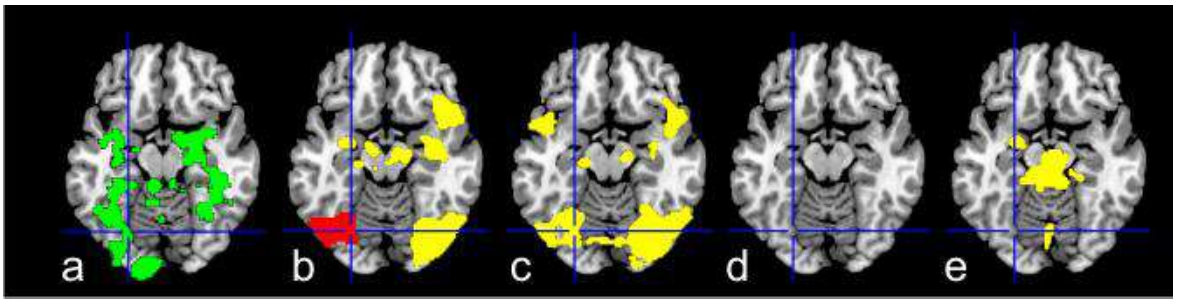





No Induction
Induction
State Report
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
Low
High
Suggestibility
Error bars: 95% Confidence Interval


No Induction
Induction
Response to Color Changing Suggestion
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Low
High
Suggestibility
Error bars: 95% Confidence Interval




a
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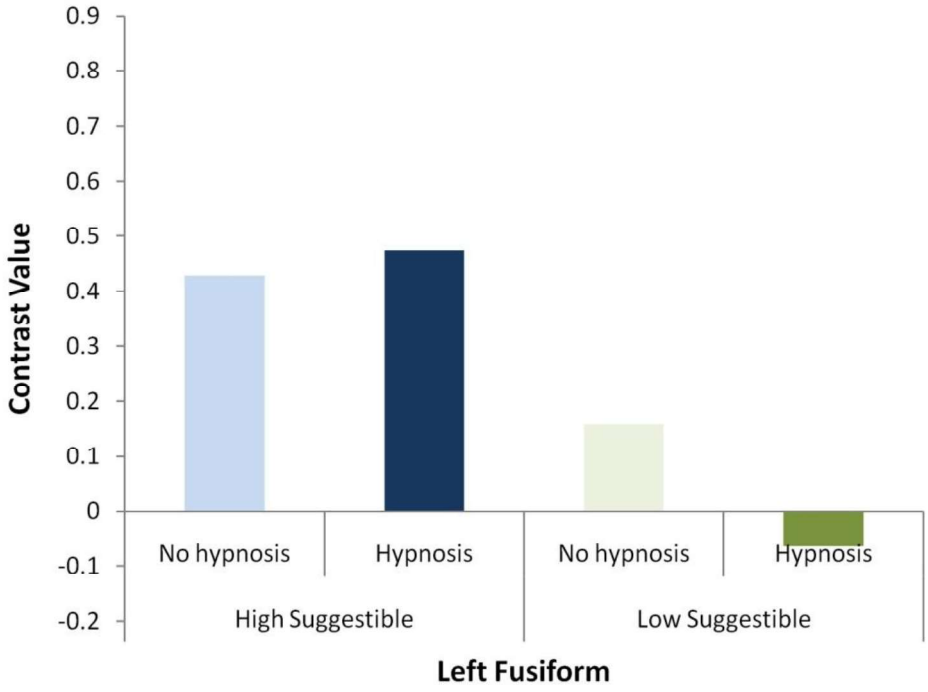
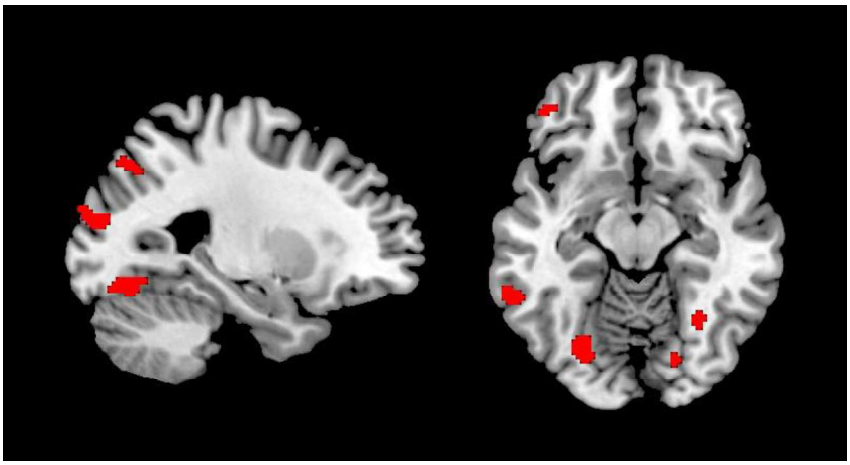
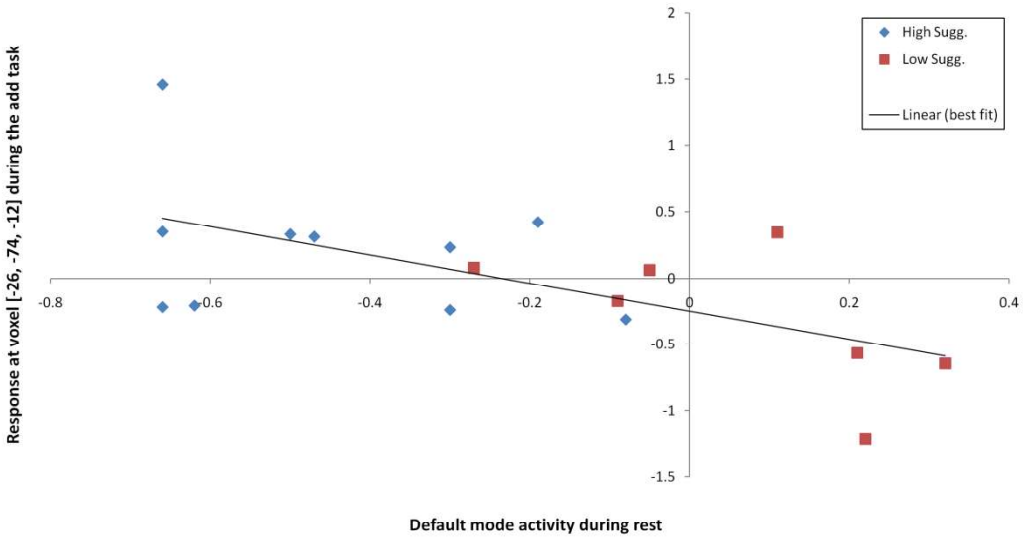

0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
Contrast Value
No hypnosis
Hypnosis
No hypnosis
Hypnosis
High Suggestible
Low Suggestible
Left Fusiform



a


Response at voxel [-26, -74, -12] during the add task
Default mode activity during rest
High Sugg.
Low Sugg.
Linear (best fit)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4

b