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HYPNOTIC DEPTH AND RESPONSE TO SUGGESTION UNDER STANDARDIZED CONDITIONS AND DURING fMRI SCANNING

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Abstract: Hypnosis is a potentially valuable cognitive tool for neuroimaging studies. However, understandable concern that Magnetic Resonance Imaging (MRI) in particular may adversely affect hypnotic procedures remains. Measurements of hypnotic depth and responsiveness to suggestions were taken using a standardized procedure that met all the requirements for functional MRI (fMRI). Testing outside the scanning environment showed reliable and stable changes in subjective hypnotic depth, with no carryover once the hypnosis had been terminated. Within-subject comparisons showed that the magnitude and pattern of these changes and the degree of responsiveness to hypnotic suggestion were not discernibly affected by the fMRI environment. It is concluded that hypnosis can be employed as a discrete and reliable cognitive tool within fMRI neuroimaging settings.

There is rapidly growing interest in employing hypnosis as a tool in cognitive neuropsychological research (Oakley, 2006) and in using brain-imaging techniques to explore hypnosis and the phenomena created by suggestion following hypnotic induction (Kihlstrom, 2003; Rainville & Price, 2003; Ray & Oathes, 2003; Spiegel, 2003; Woody & McConkey, 2003; Woody & Szechtman, 2003). To

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date most studies have used Positron Emission Tomography (PET) in combination with hypnosis to investigate auditory hallucinations (Szechtman, Woody, Bowers, & Nahmias, 1998), color processing (Kosslyn, Thompson, Costantini-Ferrando, Alpert, & Spiegel, 2000), pain perception (Hofbauer, Rainville, Duncan, & Bushnell, 2001; Rainville, Duncan, Price, Carrier, & Bushnell, 1997), voluntary motor control (Blakemore, Oakley, & Frith, 2003; Halligan, Athwal, Oakley, & Frackowiak, 2000), malingering (Ward, Oakley, Frackowiak, & Halligan, 2003), consciousness (Rainville, Hofbauer, Bushnell, Duncan, & Price, 2002), phantom-limb pain (Rosén, Willoch, Bartenstein, Berner, & Røsjø, 2001; Willoch et al., 2000), and the hypnotic state itself (Maquet et al., 1999; Rainville et al., 1999). With a notable early exception that used hypnosis to investigate phantom-limb movements (Ersland et al., 1996), functional Magnetic Resonance Imaging (fMRI) has been relatively little used in hypnosis-related research until recently. The past 2 years, however, have seen a growth in hypnosis studies using fMRI to investigate pain (Derbyshire, Whalley, Stenger, & Oakley, 2004; Raij, Numminen, Narvarnen, Hiltunen, & Hari, 2005; Schultz-Stubner et al., 2004) and attentional processes (Egner, Jamieson, & Gruzelier, 2005).

This trend seems set to continue and indeed fMRI is fast becoming the neuroimaging technique of choice for this kind of work. fMRI has a number of technical advantages over PET, particularly with regard to greater temporal and spatial resolution (Ray & Oathes, 2003). Unlike PET, it is not invasive and does not involve exposure to sources of radiation; the procedure when used experimentally is not restricted to male subjects, as is the case in the United Kingdom for PET; and the same individual can be used for repeated scans over a shorter time period. There are however some practical disadvantages to using fMRI for hypnosis studies, most notably that the participant is typically closely confined in a complete body scanning tube and the equipment is very noisy when it is operating. This creates an unpleasant, claustrophobic environment for the participant and, significantly for hypnosis studies, makes communication more difficult. More recent dedicated fMRI brain scanners have overcome some of these problems with the scanning field being limited to the head area and the development of more efficient verbal communication systems between the experimenter and the person in the scanner. Concerns remain, however, that the fMRI scanning environment could interfere with the process of hypnotic induction to a greater extent than that of PET. There is also the possibility, given the design of many neuroimaging studies, that unplanned changes in hypnotic depth could occur over the course of extended standardized hypnosis sessions, especially where these involve the delivery and removal of targeted suggestions. In addition, the need to maintain hypnosis for the long periods that many

studies require may serve to attenuate suggested phenomena that are of interest to the experimenters.

This study set out to monitor self-reported hypnotic depth with an experimental protocol (using a standardized hypnosis induction procedure based on Gruzelier, 1998) that was designed to be compatible with an fMRI scanning environment. Since fMRI experimental designs typically employ standardized periods of time within which images are acquired under controlled cognitive, sensory, and/or behavioral conditions, the protocol included measures that enable subjective changes in hypnotic depth to be monitored over time (Woody & McConkey, 2003).

To ascertain which elements of a standardized hypnotic procedure are required to produce a substantial and stable level of hypnotic depth for experimental purposes, these procedures were carried out in discrete steps. The procedure also included an evaluation of the effects on hypnotic depth of providing and removing a targeted suggestion (in this case, limb paralysis). The complete procedure was initially tested outside the scanner and then, using the same protocol, repeated in the scanning environment for a subset of the same participants. The MR scanner was operated normally to acquire fMRI data during preselected time blocks as indicated by the experimental design.

Hence, the main aim of this study was to quantify and to compare changes in hypnotic depth in response to the same protocol inside and outside an MR scanner. For this reason, imaging data acquired in the MR scanner will be separately reported.

There is currently no objective measure for the intensity of a hypnotic experience or hypnotic depth, though a number of approaches have been adopted over the years for monitoring the participant's subjective experience. McConkey, Wende, & Barnier (1999) have recently developed a more sophisticated version of an earlier technique involving the participant manually moving the pointer on a dial to indicate changes in the intensity of their experience of hypnosis and hypnotically suggested effects on a moment-to-moment basis. Unfortunately, limitations of space in the fMRI environment and the nature of the motor function tests to be used in the scanner precluded use of this device in our study. Instead, we adopted the more practical method of verbal self-reporting similar to the hypnotic-depth scale described by Le Cron (1953) and later developed as the Long Stanford Scale (Tart, 1970).

A common feature of both PET and fMRI studies is that because of their expense it is usual to pretest potential experimental participants both for their hypnotic susceptibility and for their specific ability to produce any suggested phenomena required within the experimental design. Participants had two experiences of hypnosis prior to the commencement of the study. In addition to serving as screening

procedures, these experiences provided a benchmark for participants against which their subsequent subjective depth estimations could be made.

In summary, this study was designed to provide an account of changes in subjective depth of hypnotic experience over time in an experimental protocol directly compatible with those used in fMRI neuroimaging studies when either hypnosis itself or the effects of targeted suggestions given after a hypnotic induction procedure are the principal focus of interest. In particular, we explore the predictability, stability, and strength of hypnosis and hypnotic phenomena both within and outside the scanning environment.

Method

Participants

Forty-six students scoring eight or above (out of a possible total of 12) on the Harvard Group Scale of Hypnotic Susceptibility, Form A (HGSHS:A; Shor & Orne, 1962) from the departments of Psychology and Medicine at University College London were identified from a database maintained by the authors and were invited to participate in the present study. Of these, 22 responded positively and were tested for their ability to experience a leg paralysis in response to direct suggestion in hypnosis (limb-paralysis screening). All reported an involuntary paralysis with no observable movement when they were asked to try to move the leg. Two of this group were left-handed and 2 were unavailable for further testing, leaving a group of 18 right-handed participants who took part in the first phase of the present study (off-line testing). Ten of these 18 were females. The mean age of the group was 22.3 years (range, 18–35; $SD = 4.69$) and the mean HGSHS:A score was 10.28 (range, 8–12; $SD = 1.18$). Half were tested using suggestions for leg paralysis and half for hand/arm paralysis. All paralyses were on the left side.

Following the off-line testing phase of the study, 10 of the same participants went on to be tested in the fMRI scanning environment (fMRI testing) and 8 completed the full sequence of experimental stages described below. This final subgroup was composed of equal numbers of males and females. Four had been previously tested with a hand/arm paralysis and four with a leg paralysis. All suggested paralyses in this second phase of the study were of the left hand/arm. The mean age of this group was 22.43 years (range, 18–35; $SD = 5.83$) and the mean HGSHS:A score was 10.13 (range 8–12; $SD = 1.46$).

Limb Paralysis Screening

All 22 participants who accepted the invitation to take part in the study were tested individually in an experimental room for their ability

to produce limb paralysis in response to suggestion in hypnosis. They were seated in a reclining armchair with their legs horizontal to the floor supported on a footstool. Just before the hypnotic induction, each participant was asked to describe a real or imaginary "special place" where they would feel safe and relaxed and could "spend some time for themselves" (Heap & Aravind, 2002), and detailed notes were taken. They were made aware that a limb paralysis would be suggested and that when they were asked to try to move either of their limbs they should actively try to do so. The required movement of raising the leg so that the foot was a few inches above the stool was described to them and they were then asked to perform this movement with each leg in turn. The hypnotic induction procedure that followed commenced with the participant being asked to close his or her eyes, followed by instructions for regular breathing with color imagery (breathing out a color representing tension or stress and replacing it with a "calm, tranquil" color), systematic direct muscle relaxation with suggestions of muscles "letting go," "relaxing," etc., and then descent imagery—either garden steps or lift (elevator) according to the participant's preference—accompanied by counting from one to ten. The final stage of the induction was engagement with their own special-place experience guided by the experimenter on the basis of the previously written notes. As a further hypnotic deepening procedure, a count of one to ten was used once the special place had been established, and then the participant was asked to describe aloud their experience in the special place with the suggestion that this would intensify their involvement in the experience. A left-sided leg paralysis was then suggested based on the paralysis script outline given below. The behavioral test consisted of asking the participant to try first to raise their right leg and then try to raise their left leg. They were allowed to try for 1 minute in each condition. Following this the paralysis suggestions were reversed, the behavioral test was repeated, and the special-place experience was reinstated. Finally, hypnosis was terminated with counting backwards from three to one accompanied by statements reorienting the participant to the experimental room and of returning to their everyday levels of alertness.

All participants confirmed that they had actively tried to move the appropriate leg when instructed to do so. Despite their attempts, however, none of them succeeded in raising their "paralyzed" left leg during the first behavioral test (i.e., following the paralysis suggestion)—though some showed visible signs of individual muscle twitches. In contrast, they were all able to raise their right legs. All participants moved both legs during the second behavioral test (i.e., following reversal of the paralysis suggestion). Following termination of hypnosis, participants were asked to rate the degree of involuntariness they experienced in trying to move their left leg when it

was paralyzed, in moving their left leg when the paralysis had been removed, and in moving their right leg when the left leg was paralyzed on 100mm Visual Analog Scales (VAS; where one end of the scale is labeled *completely voluntary* and the other *completely involuntary*). Overall, mean for perceived involuntariness of the failure to move during suggested paralysis was 93.00 ($SD = 7.18$); this compared with a mean involuntariness score of 17.22 ($SD = 17.15$) for movement of the left leg when the paralysis was removed and 14.67 ($SD = 17.85$) for the right leg when the left leg was paralyzed.

Off-Line Testing

The 18 participants in this first phase of the study were tested individually in an experimental room set up as it was for the limb paralysis screening sessions. To evaluate behaviors that would be possible for use in an MRI scanner, the motor response under investigation for half of the participants was the movement of an imaginary pedal by an ankle movement of their left or right foot at the rate of once every 3 seconds. For the other participants, it was the movement of an imaginary joystick once forward, once back, and then returning to the central position upon hearing an instruction to move, using the hand and wrist of their left or right hand. As before, they were told that they should always try to move the pedal/joystick in the designated way at all stages of the study when asked to do so by the experimenter. The participants were also introduced to a scale of hypnotic depth where 0 = *not hypnotized at all* and 10 = *as deeply hypnotized as you have ever been before*. They were instructed to use numbers above 10 if they felt they were hypnotized more deeply than on any previous occasion. Then followed a hypnosis and motor-response testing sequence that followed a proposed protocol for future experimental studies using fMRI. All stages of the experimental procedure incorporated 2-minute intervals (mock MRI blocks), during which no instruction was given, to represent fMRI data acquisition blocks. A hypnotic depth score was asked for at the beginning and end of each of these intervals with the request: "Please give me the number on your scale now."

The sequence of experimental stages is summarized in Table 1 and as the horizontal axis in Figure 1. For Stage 1 (MOTOR 1), the participant was asked to close their eyes and to carry out the appropriate movements with their left and right foot/hand in alternation over a 2-minute interval. Stage 2 (OPEN 1) consisted of a 2-minute rest interval with eyes open and Stage 3 (CLOSED 1) a 2-minute rest interval with eyes closed. Stages 4, 5, and 6 were based closely on a three-step model of hypnotic induction described by Gruzelier (1998). The steps are (a) fixation on an object and listening to the hypnotist's voice; (b) a letting-go procedure comprising suggestions of fatigue at continued fixation, tiredness, and eye closure, together

Table 1
Mean Hypnotic Depth Ratings During Off-Line Testing

PREHYPNOSIS			HYPNOSIS			POSTHYPNOSIS		
(1) MOTOR 1	b	0.11 (0.32)	(4) FIXATE 1	b	2.06 (1.98)	(12) CLOSED 2	b	1.39 (1.97)
	a	0.39 (0.61)		a	2.44 (1.92)		a	2.11 (2.17)
	b/a mean	0.25 (0.43)		b/a mean	2.25 (1.92)		b/a mean	1.75 (1.99)
(2) OPEN 1	b	0.50 (0.62)	(5) AFTER COUNT	b	6.94 (1.63)	(13) OPEN 2	b	0.94 (1.47)
	a	0.94 (1.06)		a	7.06 (1.83)		a	0.89 (1.28)
	b/a mean	0.72 (0.79)		b/a mean	7.00 (1.65)		b/a mean	0.92 (1.34)
(3) CLOSED 1	b	1.22 (1.35)	(6) SPECIAL PLACE 1	b	8.22 (1.73)			
	a	1.56 (1.58)		a	8.44 (1.98)			
	b/a mean	1.39 (1.44)		b/a mean	8.33 (1.81)			
			(7) MOTOR/PARAL	b	9.06 (2.29)			
				a	9.44 (2.79)			
				b/a mean	9.25 (2.51)			
			(8) MOTOR/NORM	b	8.44 (1.79)			
				a	8.50 (2.18)			
				b/a mean	8.47 (1.96)			
			(9) SPECIAL PLACE 2	b	9.00 (1.94)			
				a	9.00 (2.03)			
				b/a mean	9.00 (1.94)			
			(10) BEFORE COUNT	b	9.00 (2.09)			
				a	9.00 (2.74)			
				b/a mean	9.00 (2.39)			
			(11) FIXATE 2	b	2.94 (2.36)			
				a	2.67 (2.09)			
				b/a mean	2.81 (2.14)			

Notes. Means of depth ratings taken before (b) and after (a) each 2-minute (mock MRI) time interval and the mean rating for each of these intervals (b/a mean) are shown for all 13 experimental stages. Standard deviations are shown in parentheses.

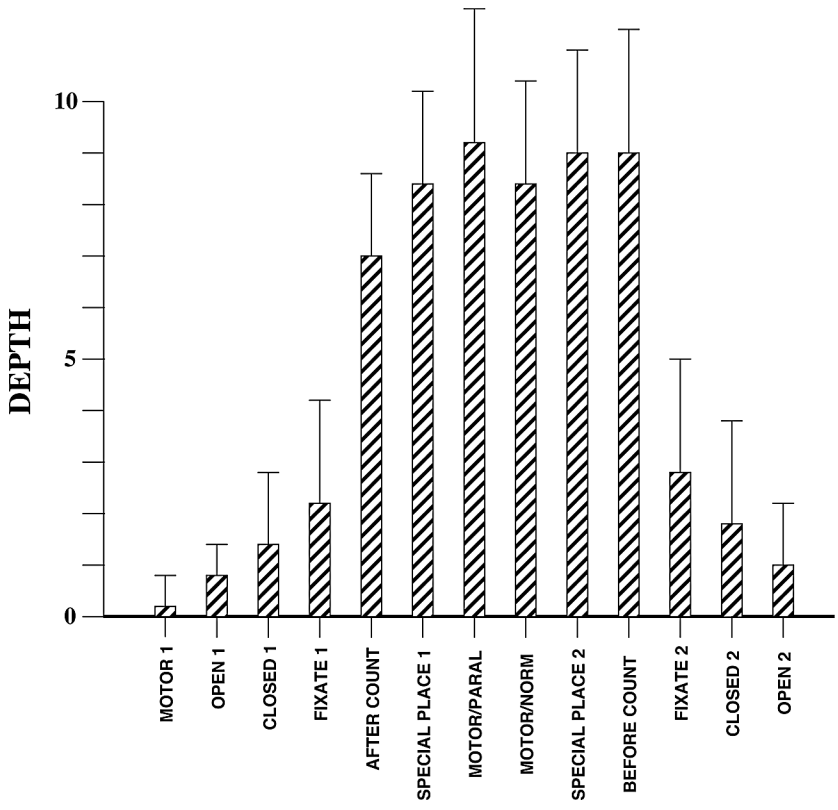

Figure 1. **Mean subjective hypnotic depth for all 13 stages of Phase 1 (Off-line testing)—based on 18 participants. See text for further explanation.**

with deep relaxation and counting; and (c) instructions for relaxed and passive imagery (see "Hypnosis Scripts" below). Our Stage 4 (FIXATE 1) consisted of a 2-minute interval preceded by instructions to the participant to continue to listen for the experimenter's voice and to fixate visually on a small spot on the wall set just above the normal line of sight. Stage 5 (AFTER COUNTING) was a 2-minute interval preceded by instructions to continue to fixate on the spot and breathe regularly, accompanied by suggestions of muscle relaxation, the eyelids becoming heavy and tired, spontaneous eye-closure, and finally by the experimenter counting from one to twenty. For Stage 6 (SPECIAL PLACE 1), the participant was asked to enter into the same special-place experience that had been used during the earlier limb-paralysis screening with the suggestion that they could this time

"let the scene unfold like in a dream" and to remain there for the next 2-minute interval. At the end of this interval, the participant was asked to "leave your special place and all the imagery associated with it but remain as relaxed and hypnotized as you are now."

In Stage 7 (MOTOR PARALYSIS), suggestions for left-sided paralysis used the paralysis-script outline presented below with appropriate substitutions of the words leg/arm, hip/shoulder, and toes/fingers for the two subgroups of participants in this part of the study. There followed a 2-minute interval during which participants attempted to move their left and right feet/hands to carry out the required movements as in Stage 1 (MOTOR 1). In Stage 8 (MOTOR NORMAL), suggestions for removal of the paralysis were given followed by a 2-minute interval during which the same motor test as in Stages 1 and 7 were repeated. Stage 9 (SPECIAL PLACE 2) was a repetition of the special-place experience plus a 2-minute interval as described for Stage 6. Stage 10 (BEFORE COUNT) involved a 2-minute interval immediately after the participant had left the special-place experience and the associated imagery but remained in the same relaxed and hypnotized state. The suggestions and instructions that were introduced at Stage 5 were then reversed, and the participant returned to "wide-awake" feelings by means of suggestions of the eyelids becoming less and less tired and heavy until the eyes felt like opening, along with counting in reverse order from twenty to one. At the end of this count, the participant was instructed as in Stage 4 to continue to listen for the experimenter's voice and to fixate visually on the spot on the wall over a 2-minute interval (Stage 11: FIXATE 2). Stage 12 (CLOSED 2) consisted of a 2-minute rest interval with eyes closed, and Stage 13 (OPEN 2) was a 2-minute rest interval with eyes open.

None of the participants were observed to move their hand or foot when attempting to carry out the intended action with their paralyzed limb—though all were capable of doing so when the paralysis was removed or when using their right side. When testing was complete, participants rated the involuntariness of their inability to move the paralyzed left hand\foot and in moving the right hand/foot when the left side was paralyzed on 100 mm VAS as in the limb-paralysis screening phase of the study. Additional 100 mm VAS were used in this phase to assess the difficulty involved in attempting to move under these conditions. For involuntariness, one end of the scale was labeled *completely voluntary* and the other *completely involuntary*. For difficulty, one end of the scale was labeled *moved easily* and the other *impossible to move*. Complete sets of involuntariness and difficulty data were collected for 15 and 16 of the participants, respectively.

The two special-place conditions were intended to represent discrete steps in the hypnotic process and similar VAS were completed by 16

of the participants at the end of the session to measure the strength of special-place imagery on the two occasions (the two ends of the scale were labeled *no imagery at all* and *very strong imagery*). In addition, these participants were asked to say whether there was imagery present immediately before the first special-place condition, during the limb-movement testing phase that followed termination of the first special-place condition, and immediately after termination of the second special-place condition. If the participant reported that imagery was present at any of these times, they were asked to rate its strength on VAS and to say if it was the special place or other imagery. If the latter, they were asked to describe the imagery they experienced at these times. The overall average time taken from the first experimental stage (MOTOR 1) to the final one (OPEN 2) was approximately 45–50 minutes.

Scripts

Hypnosis Scripts

The following are verbatim scripts used in the second phase of this study (fMRI-environment testing) for the three steps of hypnotic induction and for reversal of hypnosis, based closely on scripts used by Gruzelier and Jamieson (Graham Jamieson, November 20, 2002, personal communication). Apart from minor modifications to reflect the practical conditions of the scanning environment, such as reference to lying on the scanner table rather than reclining in a chair, the use of actual joysticks and a fixation cross instead of a spot on the wall, these scripts are identical to the ones used in the off-line testing phase of the study.

Hypnosis Step 1. Stage 4: FIXATE 1. Eyes are open, fixated on target. This follows an eyes-closed rest condition.

> Open your eyes. Just lie comfortably on the table. Keep your arms where they are, relaxed by your side with your hands holding the joysticks. Look at the cross in front of you, which I shall refer to as the target. Please look steadily at the target and while concentrating on the target pay attention to my voice. Focus your mind on what I ask you to think about—keeping your gaze fixed upon the target. If you find your mind wandering at any time, just bring your thoughts back to the target and to my words.
>
> Please give me the number on your scale now.
>
> Stay looking at the target and listening for my voice.

TEST/SCAN. Offline – silent break for 2 minutes. fMRI environment – MRI scan acquisitions; no communication from experimenter for 2 minutes, 12 seconds. Then experimenter asks: "Please give me the number on your scale now."

Hypnosis Step 2. Stage 5: AFTER COUNTING. Eye fatigue at fixation, eye closure, tiredness, relaxation, and counting.

Now you may feel you have stared for long enough but continue to look at the target for a little longer. Your eyes will feel tired and will shortly start to close. Breathe gently and easily and as you breathe out and relax more and more your eyes will begin to close all by themselves. Just let this happen and when your eyes have fully closed, please say "yes" so that I know. Breathe in and out and each time you breathe out you will feel more deeply relaxed—deeply relaxed. Feel the muscles of your face letting go . . . and the relaxation spreading through your facial muscles into your forehead and into the muscles of your scalp. Feel those muscles letting go . . . and the feelings of relaxation moving through your head . . . around and behind your eyes and into the muscles of your jaw. And the relaxation continues to move down through your body . . . to your neck . . . throat, shoulders. Your shoulders feeling limp, heavy, and relaxed.

Feelings of relaxation extend along your arms . . . down to your elbows . . . to your wrists . . . your hands . . . yours fingers. Your arms feel heavy. You feel deeply and peacefully relaxed. Your eyelids are becoming heavier and heavier . . . heavier and heavier. [IF CLOSED: "Your eyelids closed and heavy." IF NOT CLOSED: "And if they have not already closed, they will soon do so."].

Relaxation moves across your shoulders . . . into your chest . . . spreading like a wave through your body . . . moving down to your waist. Your breathing is easy and regular. Each time you breathe out you go deeper and deeper . . . feeling more and more relaxed. Waves of relaxation spread from your waist to your hips . . . to your legs . . . down to your knees . . . to your ankles . . . down to your feet . . . to your toes. As you become more and more relaxed, your body may feel heavy . . . or perhaps a little numb. You may begin to have this pleasant feeling of numbness and heaviness in your legs and feet, in your hands and arms, throughout your body . . . as though you were settling deep into the surface beneath you. Your eyelids feel heavy and tired . . . [IF CLOSED: ". . . remaining tightly closed . . . heavier and heavier. Your eyelids seem weighted down . . . pulled down by the weight." IF NOT CLOSED: ". . . and if they are not closed yet, they will begin to close soon as they feel heavier and heavier . . . just say 'yes' when they have closed completely. Your eyelids seem weighted down . . . pulled down by the weight . . . so heavy . . . just allow them to close by themselves now . . . let them close . . ." CONTINUE UNTIL subject says, "Yes."].

You are going to become even more relaxed. It is easier to relax with your eyes closed. So keep them closed now. You feel deeply relaxed . . . as you continue to listen to my voice. Just keep your thoughts on what I am saying. Soon I shall begin counting from one to twenty. As I count you will feel yourself going down further . . . and further into a deep state of relaxation, however, you will be able to do all the things you are asked to do without it disturbing your deep state of relaxation. And

you can find that background sounds bother you less and less as time goes by—just letting them slip to the back of your mind.

One . . . two . . . down, down into a deep state of relaxation . . . three . . . four . . . five . . . more and more deeply relaxed . . . six . . . seven . . . you are sinking deeper and deeper . . . eight . . . nine . . . ten . . . half way . . . eleven . . . twelve . . . thirteen . . . fourteen . . . deeply relaxed . . . hearing my voice clearly . . . fifteen . . . sixteen . . . seventeen . . . eighteen . . . deeper . . . deeper . . . more and more relaxed . . . nineteen . . . twenty . . . deeply relaxed. Just remain in that deeply relaxed state for now.

Please give me the number on your scale now.

Just relax deeper and deeper as time goes by and I will speak to you again shortly.

TEST/SCAN. Offline – silent break for 2 minutes. fMRI environment – MRI scan acquisitions; no communication from experimenter for 2 minutes, 12 seconds. Then experimenter asks: "Please give me the number on your scale now."

Hypnosis Step 3. Stage 6: SPECIAL PLACE 1. Relaxed and passive imagery.

As you relax deeper and deeper . . . allow a scene—your special place—to come to mind and begin to experience your self as part of that scene—there in your special place—just letting the scene unfold like in a dream . . . just allowing the images to shift and change as they will . . . in ever more pleasant and relaxing ways. There in your special place. [Identify individual special place and set it up using the information from the standard sheet].

If everything is O.K. and you have the feeling of being there in your special place, please let me know by saying "yes." Just remain in your special place enjoying the imagery.

Please give me the number on your scale now.

I will speak to you again shortly. Stay in your special place.

TEST/SCAN. Offline – silent break for 2 minutes. fMRI environment – MRI scan acquisitions; no communication from experimenter for 2 minutes, 12 seconds. Then experimenter asks: "Please give me the number on your scale now."

Leave your special place now and all the imagery associated with it but remain as relaxed and hypnotized as you are now—please let me know by saying "yes" when you have done that.

Reversal of hypnosis. Returning to alert feelings, eyes becoming less tired and heavy, reverse count twenty to one, and eyes opening.

In a moment, I will count back from twenty to one, and as I do just return to alert wide-awake feelings so that you are fully alert and wide

awake when I get to one. Keep your eyes closed for now, but as I count your eyes will feel less and less tired and start to open. Just let this happen, and when your eyes have fully opened please say "yes" so that I know. O.K., just returning to wide-awake, alert feelings now as I count.

Twenty . . . nineteen . . . eighteen . . . returning to wide-awake feelings . . . seventeen . . . sixteen . . . fifteen . . . more and more alert . . . fourteen . . . thirteen . . . twelve . . . eleven . . . ten . . . half way . . . nine . . . eight . . . seven . . . back to normal wide-awake feelings . . . no more heaviness or numb feelings . . . six . . . five . . . four . . . all the muscles throughout your body back to their normal state of tension and tone . . . three . . . two . . . and one, wide awake, fully alert.

Motor Test/Paralysis Scripts

The following are verbatim scripts and script outlines for motor testing and limb paralysis as used in the second phase of the study (fMRI-environment testing). Apart from the use of taped instructions cueing the joystick movements these are identical to the scripts used in the first (off-line testing) phase of the study.

Hypnosis motor test. MOTOR/NORM: arms normal. Apart from references to remaining hypnotized, this script is identical to that used for the motor test (MOTOR 1) prior to hypnosis and, for phase two only, the motor test (MOTOR 4) after hypnosis.

With your eyes closed, remaining relaxed and hypnotized. You will hear recorded instructions at regular intervals. The instruction will say: "rest," which simply means not attempting to do anything; "left," which means try to move the left joystick forwards and backwards once with your left hand each time; and "right," which means try to move the right joystick forwards and backwards once with your right hand each time. The instructions will come at regular intervals. Don't guess what is coming, just listen and follow the instructions to the best of your ability.

Please give me the number on your scale now.

In all stages, listen to the recorded instruction. Remember, sometimes you will be asked to try to move, sometimes not. Remain as relaxed and hypnotized as you are now.

TEST/SCAN. Offline – 2 minutes during which experimenter requests right and left limb movements. fMRI environment – 7 minutes, 42 seconds of MRI scan acquisitions during which prerecorded instructions are given at 3-second intervals for 7 minutes, 30 seconds: "rest," "left," and "right," which cue the appropriate subject responses. Then the experimenter says, "Please give me the number on your scale now."

Hand/arm paralysis suggestions. Script outline: Key suggestions for left arm/hand, from shoulder to tips of fingers.

1. Muscles are floppy, relaxed, so relaxed subject is unable to move but retaining their grip on the joystick. Later the word *paralyzed* is introduced—as in "that left hand and arm are becoming paralyzed from your shoulder right down to the tips of your fingers and quite unable to move—floppy and unable to move."
2. Sensation of touch remains normal and subject's grip on the joystick remains strong.
3. Muscles out of touch with subject's thoughts, wishes, and intentions—so that even if subject tries to move, the muscles will fail to respond in any way, As though the left arm and hand are no longer part of subject, "quite unable to respond."

After these suggestions (1–3 above) have been administered, subject is asked to say "yes" when he or she begins to feel the suggested changes. Suggestions continue until the "yes" response is given. Subject is then asked to allow the feelings to strengthen until the left hand/arm is "completely paralyzed from your shoulder right down to the tips of your fingers—completely unable to move the left joystick—even if you try." Suggestions continue. Subject is asked to say "yes" when paralysis is as strong as it can be. Then, "Even though your left hand and arm are paralyzed and unable to move your right hand and arm remain normal and you are able to move the right joystick easily whenever you want to."

Hypnosis motor test. MOTOR/PARAL: left arm paralyzed.

Just remain as relaxed and hypnotized as you are now with that left arm and hand paralyzed and unable to move and the right arm completely normal but retaining a grip on both joysticks.

As before, you will hear recorded instructions at regular intervals. When you hear the word "rest," just relax—do not attempt to do anything. Do not try to move either joystick but your left arm and hand will continue to feel paralyzed. Listen to the word "rest" as it is repeated but do not attempt to move either joystick.

When you hear the word, "left," please *try* to move the left joystick forwards and backwards once with your left hand each time, but your left arm and hand will remain paralyzed and unable to move the joystick, floppy and unable to move.

When you hear the word, "right," please *try* to move the right joystick forwards and backwards once with your right hand each time—your right arm and hand will remain normal and able to move easily, normally, and able to move the joystick easily.

Please say, "yes" to confirm that your left arm and hand are still completely paralyzed and unable to move at all.

Please say, "yes" to confirm that your right arm and hand are still completely normal and able to move easily.

In all stages, listen to the recorded instruction. Sometimes you will be asked to move, sometimes not. The instructions will come at regular

intervals. It is important that you follow the instructions to the best of your ability.

Please give me the number on your scale now.

TEST/SCAN. Offline – 2 minutes during which experimenter requests right and left limb movements. fMRI environment – 7 minutes, 42 seconds of MRI scan acquisitions during which prerecorded instructions are given at 3-second intervals for 7 minutes, 30 seconds: "rest," "left," and "right," which cue the appropriate subject responses. Then the experimenter says, "Please give me the number on your scale now."

fMRI-Environment Testing

For this second phase of the study, all the procedures were carried out while the participants were lying enclosed in a GE Signa 1.5 Tesla system (General Electric, Milwaukee, WI) whole-body magnet, immersed up to their waist. A quadrature birdcage head coil was used for radiofrequency transmission and reception. The fMRI scanner was housed in the Maudsley Hospital in London, and all instructions from the experimenter were conveyed via earphones from a microphone located in the scanning control room. As this proved to be a technically more reliable method for use in the scanner, all participants were tested in this phase of the study for hand and wrist movements using standard computer analog joysticks adapted to remove most metal. The filtered signal from each joystick was interfaced to the computers via a custom-built interface box. As with the imaginary joysticks used in off-line testing, they were to be moved once forward, once backward and returned to rest upon verbal instruction. As an actual joystick was available for each hand, the additional suggestion was given that irrespective of paralysis suggestions the participant's fingers/hand would retain their grip on the relevant joystick throughout. The verbal instructions pertaining to the joystick movements were also simplified and presented via a digital recording for this part of the study (see motor test/paralysis scripts above).

In contrast to the off-line phase, we included a fourth stage of motor testing after reversal of the hypnotic state in the fMRI-testing phase. This additional stage was introduced to explore any carryover effects on brain function of the suggestions of limb paralysis after removal of the suggestion and reversal of the hypnotic state. Due to time limitations, this stage was acquired in only 6 subjects.

Each of the four motor-testing blocks, during which MR activations were acquired, comprised a total of 15 30-second epochs (five "rest," five "right," and five "left"), each epoch consisting of 10 consecutive repetitions of the relevant command repeated at 3-second intervals.

These epochs were presented in a pseudorandomized order. The total stimulus time for each motor block was 7 minutes, 30 seconds in a total scan time of 7 minutes, 42 seconds.

The other five stages of the testing protocol up to the point at which hypnosis was terminated were each followed by a 2-minute 12-second block of MR acquisition (including an initial 12 seconds of dummy acquisitions). For each of these five nonmotor stages of the experimental protocol, this resulted in five blocks of image acquisition that were concatenated into a single experimental run to allow contrasts of discrete stages. It is important to note that although the scan data are not reported the scanner was activated in the normal way during each of the scanning periods that were embedded in the testing protocol. The final nonmotor stage of the procedure (posthypnosis, eyes open) did not include a scanning block. Further, as part of the normal procedure for checking for scanner drift, a standardized visual/auditory (VISAUD) stimulus set consisting of a changing checkerboard visual display and spoken words that had not occurred during off-line testing was presented once before testing commenced, once in the middle of testing (immediately before the reversal of hypnosis), and once when testing was complete (stimulus duration 4 minutes, 48 seconds in a total scan time of 4 minutes, 56 seconds). In addition, prior to the commencement of baseline motor testing localizer scans, high resolution GE (Gradient Echo) scans for fMRI image registration, and a high resolution three-dimensional MR volume, using a T1-weighted SPGR (Spoiled Gradient Recall) acquisition strategy, were acquired.

Apart from the above mentioned differences, and the use of a projected fixation cross, all the stages that formed part of the procedure for this phase of the study were carried out exactly as described for the off-line testing phase and are identified here with the same names. To accommodate the testing protocol within the time available for scanning, some of the later stages used in the off-line testing were dropped. The fMRI-environment testing phase of the study commenced with three prehypnosis stages: MOTOR 1 testing, followed by OPEN 1 and CLOSED 1. There were then five hypnosis stages: FIXATE 1, AFTER COUNT, SPECIAL PLACE 1, MOTOR NORMAL, MOTOR PARALYSIS. The sequence as described above is identical to the off-line procedure up to and including SPECIAL PLACE 1. In this second phase of the study, motor testing with both limbs normal (MOTOR NORMAL) preceded testing with the left limb paralyzed (MOTOR PARALYSIS). This was to avoid any possible carryover effects of hypnotic paralysis into normal limb-movement testing in anticipation of the proposed fMRI analysis. Following MOTOR PARALYSIS, the hypnosis reversal procedure that was described in the off-line testing phase was carried out. The final stage of the procedure was an eyes-open alert state (OPEN 2), and for 6 of the participants there was a further posthypnotic

motor block (MOTOR 4). This sequence of stages is summarized in Table 2 and in the horizontal axis to Figure 2. Even with these amendments, because of varying delays between each of the stages that were introduced by operating requirements of the scanner itself, the inclusion of VISAUDs, localizer scans, structural scans and the longer motor testing intervals compared to Phase 1, the duration of this part of the study for the 6 participants who completed all ten stages was approximately 2 hours and 15 minutes within which there was a minimum of 1 hour 43 minutes of scanning time (the other two participants omitted the final motor block, corresponding to 7 min 42 seconds less of completed MR scanning).

Corresponding to the procedure in the off-line testing phase of the study, hypnotic depth measurements were taken immediately before and after each block of MR acquisition. In addition, a single hypnotic depth measurement was taken immediately after the reversal of hypnosis in the alert, eyes-open state (OPEN 2). Postsession VAS measures were again used to assess the involuntariness and difficulty of attempted joystick movements during the left-hand paralysis condition, the strength of special-place imagery and the strength and nature of imagery experienced before the special-place condition and during joystick movement testing after its termination. Full sets of data were collected for all 8 participants on all measures except for right arm, special place, and posthypnosis measures for one of them.

All data analysis was carried out using SPSS Version 11.03 for Macintosh OSX. The criterion for statistical significance was set at $p < .05$ (two-tailed).

Results

Off-Line Testing

Mean hypnotic depth ratings before (b) and after (a) each of the 2-minute intervals (mock MRI blocks) embedded in the 13 stages of the off-line screening phase of the study are shown in Table 1. To test for changes in subjective hypnotic depth within mock-MRI intervals and across all stages of the experimental procedure, a 13 (stages – within subjects) $\times$ 2 (before interval, after interval – within subjects) $\times$ 2 (arm, leg – between subjects) analysis of variance (ANOVA) was performed on the depth ratings (b and a values shown in Table 1). In the analysis that follows, the term *stage* is used to refer to stages of the overall procedure (MOTOR 1, OPEN 1, CLOSED 1, etc.) and *interval* refers to the 2-minute mock-MRI intervals that accompanied each of these stages.

A significant main effect of hypnotic depth was found for stages, $F(12, 192) = 177.89$, $p < .001$, and for interval, $F(1, 16) = 4.70$, $p < .05$.

Table 2
Mean Hypnotic Depth Ratings During fMRI Environment Testing

PREHYPNOSIS			HYPNOSIS			POSTHYPNOSIS	
(1) MOTOR 1	b	0.50 (0.53)	(4) FIXATE 1	b	1.13 (1.36)	(9) OPEN 2	0.57 (0.53)
	a	1.00 (1.07)		a	1.25 (1.28)		
	b/a mean	0.75 (0.76)		b/a mean	1.19 (1.31)		
(2) OPEN 1	b	0.63 (0.74)	(5) AFTER COUNT	b	6.75 (1.49)	(10) MOTOR 4	b 1.00 (0.63)
	a	0.63 (0.74)		a	6.88 (1.89)		a 1.17 (0.41)
	b/a mean	0.63 (0.74)		b/a mean	6.81 (1.60)		b/a mean 1.08 (0.49)
(3) CLOSED 1	b	0.88 (0.83)	(6) SPECIAL PLACE 1	b	8.13 (1.36)		
	a	1.38 (1.30)		a	7.88 (2.17)		
	b/a mean	1.13 (1.06)		b/a mean	8.00 (1.71)		
			(7) MOTOR/PARAL	b	8.71 (0.76)		
				a	8.57 (0.79)		
				b/a mean	8.64 (0.69)		
			(8) MOTOR/NORM	b	8.43 (0.79)		
				a	7.71 (0.49)		
				b/a mean	8.07 (0.61)		

Notes. Means of depth ratings taken before (b) and after (a) each of the MRI scanning blocks and the mean rating for each of the blocks (b/a mean) are shown for all experimental stages except for posthypnosis Stage 9 (OPEN 2) where a single depth rating was taken. The b-a duration is 7 minutes, 42 seconds for MOTOR test scans (Stages 1, 7, 8, and 10) and 2 minutes, 12 seconds for Stages 2, 3, 4, 5, and 6. Standard deviations are shown in parentheses.

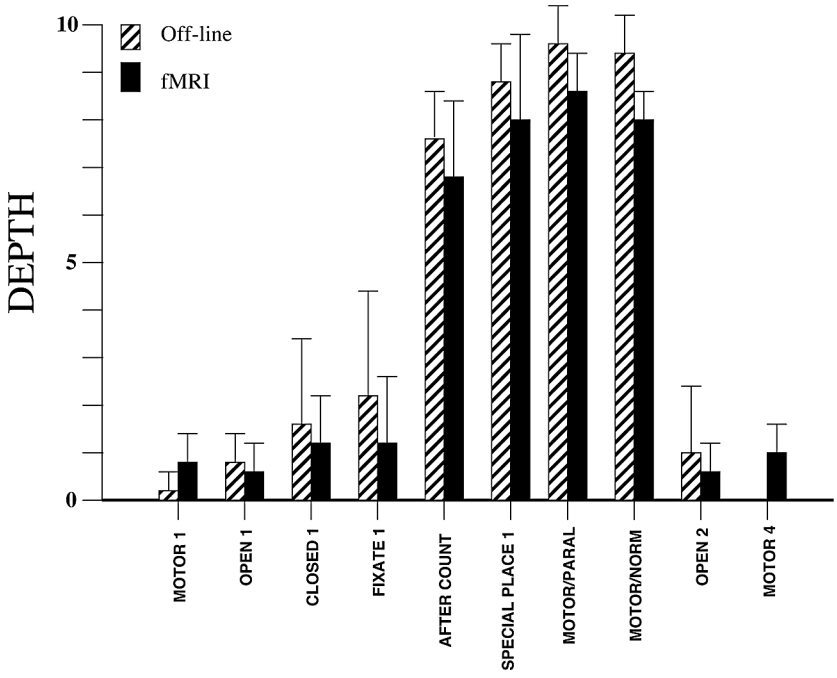

Figure 2. **Mean subjective hypnotic depth at corresponding stages in Phase 1 (Off-line testing) and Phase 2 (fMRI Testing) for 8 participants. The final stage (MOTOR 4) was present only in fMRI testing and for 6 participants. See text for further explanation.**

There was also a significant interaction between stages and interval, $F(12, 192) = 1.98$, $p < .05$. No other significant effects were found for hypnotic depth. In order to explore the interval effect further, a separate 5 (stages) $\times$ 2 (before interval, after interval) within-subjects effects ANOVA was carried out on the nonhypnosis conditions (prehypnosis and posthypnosis in Table 1). A significant main effect on hypnotic depth was again found for stages, $F(4, 68) = 9.1$, $p < .001$, and for interval $F(1, 17) = 15.75$, $p < .001$, and for the interaction between the two, $F(4, 68) = 2.77$, $p < .05$. An additional 8 (stages) $\times$ 2 (before interval, after interval) within-subjects effect ANOVA conducted for the hypnosis condition found a significant effect of depth once more for stages, $F(7, 119) = 116.94$, $p < .001$, but not for interval. Self-ratings of depth of hypnosis thus vary significantly with the stage of testing both outside and within formally induced hypnosis. However, significant changes in depth from before to after the 2-minute interval are

restricted to the nonhypnosis conditions. Table 1 illustrates that with the exception of OPEN 2 mean hypnotic depth increased across the interval in the nonhypnosis conditions.

Subsequent analysis of the depth ratings was carried out using the mean values for each of the 2-minute intervals. These means (plus *SD*s) are shown graphically in Figure 1. Related-means *t* tests were used to evaluate depth changes over the various stages of the session. Compared to the initial eyes-open (OPEN 1) stage, there is a significant increase in depth during eye-fixation (FIXATE 1), $t(17) = -4.57$, $p < .001$. The numerically larger increase in depth following the eye-closure and counting induction (AFTER COUNT) is significant compared to both the initial eyes-closed stage (CLOSED 1), $t(17) = -14.43$, $p < .001$, and depth during fixation (FIXATE 1), $t(17) = -10.85$, $p < .001$. The introduction of the special-place experience (SPECIAL PLACE 1) produces a further significant, albeit numerically smaller, increase in depth when compared to the eye-closure and counting procedure (AFTER COUNT), $t(17) = -6.23$, $p < .001$. The introduction of limb paralysis (MOTOR/PARAL) also results in a further small but significant increase in depth compared to the preceding special place (SPECIAL PLACE 1), $t(17) = -3.34$, $p < .01$. Conversely, there is a numerically large and significant drop in depth scores at the end of the hypnosis condition from the interval sampled just before the reversal of eye-closure and counting procedure (BEFORE COUNT) to the second fixation stage (FIXATE 2), $t(17) = 10.83$, $p < .001$, to produce depth levels at FIXATE 2 that are not significantly different from the first fixation stage (FIXATE 1). Consistent with this lack of persistence of hypnotic depth following the hypnosis reversal procedure, the depth at the posthypnosis eyes-closed stage (CLOSED 2) is not significantly different from the comparable prehypnosis eyes-closed stage (CLOSED 1).

During the hypnosis condition when the left limb was paralyzed (MOTOR/PARAL), related-means *t* tests revealed a significant difference in the mean strength of the sense of involuntariness reported by participants when attempting to move their left or right limbs, left limb, 89.07, $SD = 15.09$; right limb, 5.87, $SD = 9.51$; $t(14), = 17.87$, $p < .001$, and in the difficulty of movement, left limb, 87.50, $SD = 19.79$; right limb, 16.31, $SD = 20.19$; $t(15) = 9.652$, $p < .001$. No significant differences were found due to whether the upper or lower limbs (arm vs. leg) were used for motor-paralysis testing. Also, there was no significant difference in mean strength of imagery reported between the first (SPECIAL PLACE 1, 76.19, $SD = 20.35$) and the second time that special-place imagery was introduced (SPECIAL PLACE 2, 83.56, $SD = 15.91$). Two participants reported spontaneously experiencing special-place imagery in hypnosis before SPECIAL PLACE 1 (mean strength, 49.0; range, 39–59) and 7 reported the persistence of special-place imagery after SPECIAL

PLACE 2 (mean strength, 52.3; range, 29–93), but none reported special-place imagery during the MOTOR/PARAL stage of testing. Imagery other than special place was reported by 1 participant before SPECIAL PLACE 1 (image of "descending through water," strength, 71) and another participant reported other imagery ("like watching crystals form," strength, 59) after SPECIAL PLACE 2. Two participants reported other imagery during MOTOR/PARAL—one of "visualizing left paralyzed leg" (strength, 64) and the other the "image of a computer joystick in my left hand" (strength, 70).

fMRI-Environment Testing

Mean hypnotic depth ratings were taken immediately before and after the MRI acquisition blocks for the 8 participants in each of the first 8 stages of this phase of the study that were shared with the off-line study (see Table 2). In the following analysis, *stage* refers to the stages of the overall procedure, and *block* refers to the MRI acquisition blocks. In order to explore changes in subjective hypnotic depth within MRI acquisition blocks and across stages separately for the prehypnosis and the hypnosis conditions, two ANOVA designs were used. A 3 (stages) $\times$ 2 (before block, after block) ANOVA carried out on the hypnotic depth measurements for the prehypnosis condition showed no significant effect for either stages or blocks. A similar 5 (stages) $\times$ 2 (before block, after block) ANOVA for the hypnosis condition, however, found a significant depth of hypnosis effect for stages, $F(4, 24) = 58.95$, $p < .001$, but again not for blocks. As in the off-line testing phase, therefore, depth of hypnosis varied significantly over stages within the hypnosis condition but remained stable during the blocks of MR acquisition. The significant changes in depth across stages and within the 2-minute (mock MRI) intervals seen in the off-line testing phase outside hypnosis, however, are no longer present in this second phase of testing.

Mean hypnotic depth scores for the 8 participants who progressed to the second phase of the study are shown for the 9 stages common to both phases (off-line testing and fMRI-environment testing) of the study in Figure 2 (for comparison with off-line testing, the fMRI-environment testing data for MOTOR NORMAL and MOTOR PARALYSIS are shown in Figure 2 and Table 2 in reverse of the actual order of testing). A 9 (stages) $\times$ 2 (phases) within-subjects ANOVA found a significant overall effect for stages, $F(8, 40) = 294.39$, $p < .001$. Although inspection of the data in Figure 2 suggests slightly lower depth measurements during fMRI-environment testing for all stages except the initial motor test (MOTOR), there was no significant effect for experimental phase, that is, when comparing off-line and fMRI environment testing results across stages.

The data for this second phase of the study allow a comparison of mean subjective hypnotic depth before and after hypnosis as a means of investigating the possibility of carry-over of hypnotic effects from the hypnosis condition to the posthypnosis condition. Related-means t tests comparing mean hypnotic depths at OPEN1 versus OPEN2 and at MOTOR 1 versus MOTOR 4 revealed no significant difference in the before and after measures indicating that there is no carryover of subjective hypnotic depth from the hypnosis condition to the posthypnosis condition.

Related-means t tests were used to explore the strength of the reported experience of involuntariness and difficulty in moving the right or left joystick during paralysis of the left arm (MOTOR/PARAL) for these 8 participants in both phases of the study (off-line testing and fMRI-environment testing). There were no significant differences comparing off-line with fMRI-environment testing on either involuntariness or difficulty measures. The differences between the left and right limb were, however, significant for both phases of the study for involuntariness (off-line testing: left limb, 94.88, $SD = 11.32$; right limb, 6.43, $SD = 13.58$; $t[6] = 13.82$, $p < .001$. fMRI-environment testing: left limb, 92.75, $SD = 10.65$; right limb, 1.00, $SD = 1.00$; $t[7] = 23.8$, $p < .001$) and for difficulty (off-line testing: left limb, 97.50, $SD = 3.25$; right limb, 10.43; $SD = 12.69$; $t[6] = 17.04$, $p < .001$; fMRI-environment testing: left limb, 96.38, $SD = 4.57$; right limb, 0.72, $SD = 0.95$; $t[7] = 57.83$, $p < .001$). The mean strength of imagery in these same participants during the special-place stage (SPECIAL PLACE 1) for off-line testing, 87.00, $SD = 6.73$, was not significantly different from that for fMRI testing, 81.89, $SD = 17.71$. In the fMRI-environment testing phase, none of the 8 participants reported spontaneous special-place imagery either before the first special-place stage (SPECIAL PLACE 1) or during motor testing while the left hand/arm was paralyzed (MOTOR/PARAL). Three participants reported nonspecial-place imagery before the SPECIAL PLACE 1 stage of testing ("walking down a staircase" (visual), strength 100; "random visual imagery, e.g., faces," strength, 81; "descending stairs," strength, 13), but none reported other imagery during MOTOR/PARAL.

Discussion

The present study examined responsiveness to suggestion and subjective depth of hypnotic experience over time in an experimental protocol designed to allow hypnotic phenomena to be investigated both outside the fMRI-scanning environment (off-line testing) and during the fMRI-scanning procedure itself (fMRI-environment testing). The main aim was to formally establish whether a typical fMRI-scanning environment produces any potentially adverse effects on

both subjective hypnotic depth and the participants' ability to respond to specific suggestions. A number of features of the fMRI environment might be expected to have a negative impact on both of these. The most notable are the noise and the claustrophobic environment of the scanner itself, but other possibly adverse factors include the need to deliver instructions and suggestions to the participant remotely via earphones, the longer time taken to complete the tests, and the distraction caused by other events related to scanning protocols, such as VISAUDs, localizer scans, and structural scans. The results obtained in the two phases of the study, however, confirm that none of these features had any significant effect on either hypnotic depth or responsiveness to suggestions.

The sequence and magnitude of the changes in subjective hypnotic depth across the various stages of the procedure both within and outside hypnosis were the same in the fMRI environment as they had been during off-line testing in a normal experimental setting. Importantly, once the hypnotic procedures had been initiated, subjective depth remained stable within both the mock-MRI intervals of the off-line-testing phase and the actual MRI-acquisition blocks in the fMRI environment. The latter is particularly notable, because some of these MRI blocks (those used for motor testing) were 7 minutes and 42 seconds long compared to the standard 2-minute mock-MRI intervals used in the off-line phase of the study. There was no evidence from either phase of the study of any carryover of subjective hypnotic depth effects from the hypnosis to the posthypnosis condition.

Participants reported experiencing the suggested limb paralysis with the same degree of involuntariness and difficulty in initiating movement in both phases of the study, and there was no apparent effect of the fMRI environment on strength or persistence of suggested special-place imagery. It was also a consistent observation from both phases of the study that the introduction of special-place imagery and of testing for hypnotic paralysis were accompanied by small but significant increases in hypnotic depth. The level of spontaneous imagery was low in both phases of the study, and none of the participants reported imagery of either the special place or of any other type during motor testing in hypnosis. Nevertheless, the occurrence of unintended imagery, particularly the persistence of special-place imagery if it is used, should be monitored in imaging studies as its presence will affect the pattern of activity associated with intended experimental conditions.

One observation that emerged from both phases of this study that has practical significance for both clinical and experimental applications is that the most significant effect on hypnotic depth was contributed by the combination of eye closure, relaxation, and counting procedures used as the second step of our standardized

hypnotic-induction procedure. Hence, where time is a consideration and the achievement of hypnotic depth is the major aim, procedures equivalent to induction Step 1 (eye fixation) and induction Step 3 (in our study represented by the special place) could be omitted. The first step could perhaps be replaced with a simple eye-closure request or instruction. It remains possible, however, that this step represents an important part of the hypnotic process, such as the engagement of frontal attentional networks (Gruzelier, 1998), that is not reflected in the magnitude of subjective hypnotic depth change associated with it. Equally, there may be good reasons, especially in clinical settings, to institute the special-place procedure, other than for increasing hypnotic depth. Kalisch et al. (2005), for example, have recently shown in an fMRI experiment that the special-place procedure used in the present study is effective in attenuating the subjective and physiological correlates of anticipatory anxiety and reduces responsiveness to pain stimuli.

Overall, these data provide a clear picture of the changes in subjective hypnotic depth associated with a standardized three-step hypnosis induction procedure, such as that described by Gruzelier (1998), and demonstrate that this pattern of changes can be maintained in the fMRI environment without reduction in depth of hypnosis. In addition, our study provides the first direct evidence that an fMRI environment and the temporal constraints it imposes do not seem to impair the participants' ability to experience the effects of hypnotic suggestion, though this observation needs to be replicated and extended beyond limb paralysis and special-place imagery. This outcome supports the view that hypnosis and suggestion within hypnosis are reliable tools for use in fMRI neuroimaging studies.

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Hypnosetiefe und Reaktion auf Suggestion unter standardisierten Bedingungen und während fMRT-Messungen

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Zusammenfassung: Hypnose ist ein möglicherweise sehr wertvolles kognitives Instrument für bildgebende Studien. Allerdings existiert Besorgnis darüber, dass insbesondere bei Magnetresonanztomographie-Messungen hypnotische Vorgänge beeinträchtigt werden könnten. Messungen der hypnotischen Tiefe und Ansprechbarkeit auf Suggestionen wurden im Rahmen einer standardisierten Prozedur erhoben, welche allen Vorgaben der funktionellen Magnetresonanztomographie-Messungen gerecht wurde. Tests außerhalb des Scanners wiesen zuverlässige und stabile Veränderungen der subjektiven Hypnosetiefe auf. Es gab keine Folgeeffekte nachdem die Hypnose beendet worden war. Vergleiche innerhalb einzelner Versuchspersonen zeigten, dass Größe und Art dieser Veränderungen sowie das Ausmaßder Ansprechbarkeit auf hypnotische Suggestionen von der fMRT-Umgebung nicht erkennbar beeinträchtigt wurden. Daraus wird geschlossen, dass Hypnose als eigenständiges und zuverlässiges kognitives Instrument im Rahmen von fMRT -Bildgebungsstudien eingesetzt werden kann.

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La profondeur de l'état hypnotique et la réponse à des suggestions dans des conditions standardisées et durant un examen d'imagerie par résonance magnétique fonctionnelle (IRMF)

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Résumé: L'hypnose constitue un outil cognitif potentiellement précieux pour la recherche en neuro-imagerie. On continue pourtant de s'inquiéter à juste titre du fait que l'examen par IRM (imagerie par résonance magnétique), en particulier, puisse avoir une incidence négative sur la procédure hypnotique. Des mesures ont été prises de la profondeur de l'état hypnotique et de la réceptivité aux suggestions, à l'aide d'une procédure

standardisée satisfaisant à toutes les exigences de l'imagerie par résonance magnétique fonctionnelle (IRMF). Les essais mené hors scintigraphie ont montré des changements fiables et stables dans la profondeur subjective de l'état hypnotique, sans effet résiduel une fois l'hypnose terminée. Les comparaisons chez un même sujet ont démontré que l'ampleur et le modèle de ces changements et le degré de réceptivité à la suggestion hypnotique n'étaient pas affectés de façon notable par l'IRMF. On a pu conclure qu'en neuro-imagerie, l'hypnose peut être employée comme outil cognitif distinct et fiable.

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La profundidad hipnótica y la respuesta a las sugestiones durante condiciones estandarizadas y durante el fMRI

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Resumen: La hipnosis es una herramienta cognitive potencialmente valiosa para los estudios de imagen cerebral. Sin embargo, existe una preocupación comprensible de que la Imagen de Resonancia Magnética (MRI) en particular pueda afectar adversamente los procedimientos hipnóticos. Tomamos medidas de profundidad hipnótica y responsividad a las sugestiones usando un procedimiento estandarizado que cumple todos los requisitos para el MRI funcional (fMRI). La prueba afuera del ambiente de muestreo mostró cambios estables y confiables en la profundidad hipnótica subjetiva, sin ningún efecto ulterior ya que la hipnosis había terminado. Las comparaciones intra-sujetos mostraron que la magnitud y patrón de estos cambios y el grado de respuesta a las sugestiones hipnóticas no fueron sensiblemente afectadas por el ambiente del fMRI. Se concluye que se puede emplear a la hipnosis como una herramienta cognitiva específica y confiable dentro del ambiente de muestreo del fMRI.

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