Metacognition of intentions in mindfulness and hypnosis

Peter Lush[1,2,*], Peter Naish[1] and Zoltan Dienes[1,2]

[1]Sackler Centre for Consciousness Science, University of Sussex, Brighton, UK; [2]School of Psychology, University of Sussex, Pevensey Building, Falmer BN1 9RH, UK

*Correspondence address. Peter Lush, School of Psychology, University of Sussex, Pevensey Building, Falmer BN1 9QH, UK. Tel: +44 1273 678916; E-mail: p.lush@sussex.ac.uk

Abstract

In a famous series of experiments, Libet investigated the subjective timing of awareness of an intention to move, a task that can be considered a metacognitive judgement. The ability to strategically produce inaccurate metacognitions about intentions has been postulated to be central to the changes in judgements of agency common to all hypnotic responding. Therefore, differences in hypnotisability may be reflected in Libet's measure. Specifically, the ability to sustain inaccurate judgements of agency displayed by highly hypnotisable people may result from their having coarser higher order representations of intentions. They, therefore, should report a delayed time of intention relative to less hypnotisable individuals. Conversely, mindfulness practice aims at accurate metacognition, including of intentions, and may lead to the development of finer grained higher order representations of intending. Thus, the long-term practice of mindfulness may produce an earlier judgement of the time of an intention. We tested these groups using Libet's task, and found that, consistent with predictions, highly hypnotisable people reported a later time of intention than less hypnotisable people and meditators an earlier time than non-meditators. In a further two studies, we replicated the finding that hypnotisable people report later awareness of a motor intention and additionally found a negative relationship between trait mindfulness and this measure. Based on these findings, we argue that hypnotic response and meditation involve opposite processes.

Key words: sense of agency; judgements of agency; Libet; hypnosis; mindfulness; meditation

Introduction

Voluntary actions can be distinguished from involuntary or reflex actions in that they can, on reflection, be accompanied by awareness of intending to act, as investigated in the famous experiments of Libet and colleagues (Libet *et al.*, 1983). In these studies, participants reported the time at which they experienced an "urge" to move (W) while watching an oscilloscope "clock." As such, Libet's W timing can be interpreted as a measure of temporal metacognition and as a chronometric measure of the sense of agency (Wolpe and Rowe, 2014). We use it to investigate the nature of both hypnotic responding and mindfulness, which both have, we argue, essential metacognitive components. We will argue for the relationship between W and both hypnotic responding and mindfulness via higher order thought theory.

Higher order thoughts target first order intentions

Higher order theories of consciousness relate metacognition to conscious experience by arguing that a mental state becomes conscious by virtue of a second-order process that is about it (Lau and Rosenthal, 2011). For example, a visual percept (e.g., "a red ball," the first-order state because it is about the world) becomes conscious by one becoming aware of it with a higher order state (e.g., one with the content, "I see a red ball," higher order because it is about a mental state). Therefore, Libet's W judgements can be interpreted as depending on higher order

states targeting first-order intentions. Changes in higher order processing (i.e., involving states about mental states) may be expected to result in changes to the content of consciousness. Conversely, if normal events elicit unusual experiences, it may be hypothesised that higher order states are being employed in unusual ways.

Hypnotic responding is due to changes in self-monitoring

Differences in the ability to experience hypnotic effects are considerable, and they can be measured using standardised scales based on the number of hypnotic suggestions to which an individual responds (Laurence et al., 2008; Woody and Barnier, 2008). As will be explained, it is possible to describe the unusual experiences of hypnosis as resulting from changes in higher order states. The classical hypnotic suggestion effect is characterised by the experience of involuntariness, with control instead attributed to the hypnotist or to some feature of the hypnotic suggestion (Weitzenhoffer, 1980). Alterations of the sense of agency are, therefore, central to hypnotic responding (Polito et al., 2013), and this may provide a clue as to where to look for finding reliable predictors of hypnotisability.

A broad distinction can be made between theories of hypnosis that propose that hypnotic responding is intentional and those that do not. For example, according to dissociated control theory (Woody and Bowers, 1994), hypnosis causes a dissociation between action generation and executive control systems. In this case, metacognitive judgements of agency during hypnotic responding are accurate, as subjects genuinely have no executive control over the action, and judge that they do not. A second theoretical approach argues that hypnotic responding is intentional (or under executive control), and is due to changes in self-monitoring (e.g, Spanos, 1986; Kihlstrom, 1992). The common denominator of the latter group of theories has been dubbed "cold control" (Dienes, 2012). The word "cold" is used, because the theory supposes that intentional actions are carried out in the absence of an appropriate higher order thought (HOT).

Cold control theory draws on Rosenthals's HOT theory (Rosenthal, 2005) and proposes that the changes in the conscious experience of intending that define a hypnotic experience are the result of inaccurate HOTs about not having a first-order intention. Therefore, hypnotic responding is made possible by an ability to relinquish metacognition related to voluntary behavior in response to a hypnotic situation (Dienes, 2012). So, on this account, an ideomotor suggestion to raise an arm results in a normal first-order intention to raise the arm (cf. Schlegel et al., 2015). However, the intention fails to become conscious because there is no accurate HOT that might ordinarily be directed at the first-order intention if a voluntary movement were being attended to ("I am intending to move my arm"). There is in fact a directly contrary HOT, appropriate to the hypnotic situation, but inappropriate to the facts ("I am not intending to move my arm," which constitutes a HOT broadly construed as a state about the nature, including non-existence, of first-order states; contrast Rosenthal, 2005). So, hypnotic responding requires an inaccurate HOT related to an intention, not merely the absence of an accurate HOT. If highly hypnotisable people are better able to form inaccurate HOTs of intending, this ability may be supported by their having a generally weaker coupling of HOTs to first-order intentions (Semmens-Wheeler and Dienes, 2012). Such a weaker coupling may be reflected by later awareness of an intention to move.

Awarenesss of intentions in mindfulness meditation

Mindfulness can be defined as the cultivation of equanimous awareness of present experience as present experience, while sustaining that experience or letting it go according to task purposes (e.g., Williams and Kabat-Zinn, 2013). For example, if the aim is to attend to the breath, when experiences unrelated to the breath arise, they are judged as task unrelated and allowed to pass; but experiences of the sensation of the breath on the lip are judged as appropriate and sustained. These judgments are made without feelings of disappointment or triumph. Mindfulness meditation is thus intrinsically an exercise in the (metacognitive) control and monitoring of mental processes (Bishop et al., 2004; Gethin, 2015; Jankowski and Holas, 2014; Teasdale, 1999). But apart from a recent report that mindfulness meditation enhances metacognitive abilities (Baird et al., 2014), and evidence that mindfulness is associated with a more fine-grained awareness of emotions (e.g., Hill and Updegraff, 2010), there has been surprisingly little work relating meditation practice to metacognitive measures. Awareness of intentions constitutes part of the four foundations of mindfulness (Analayo, 2003). The four foundations are: First, awareness of the body in terms of its parts, postures, and movements; second, awareness of feelings, specifically as pleasant, unpleasant, or indifferent; third, awareness of mental states broadly in terms of whether they are conducive to flourishing or not ("deluded," "concentrated," etc.); and, fourth, awareness of mental states classified in a number of detailed ways to bring out their nature and relation to flourishing (Analayo, 2003). The final category includes intentions. (The progression is from the more concrete given content of a mental state to more abstract mental state properties claimed as relevant to flourishing by Buddhist theory.) Buddhist scholars have also argued that the practice of mindfulness should lead to an enhanced awareness of action intentions (Dreyfus, 2013). Therefore, mindfulness meditators might be expected to have an earlier awareness of an intention to move (cf. Jo et al., 2015, who report that meditators have greater access to the negative deflections of the slow cortical potentials averaged to produce the early readiness potential which is associated with conscious intentions to act).

Mindfulness and hypnotic response are in tension

In summary, we have argued that highly hypnotisable people on the one hand, and meditators on the other, lie at two ends of a spectrum of metacognition or accurate HOTs related to intention (see Lifshitz et al., 2014, and Raz and Lifshitz, 2016, for a discussion of different theoretical perspectives on the relation between meditation and hypnosis). In support of this assertion, it has been found that meditators score lower on hypnotisability scales than non-meditators and that highly hypnotisable people score lower on trait mindfulness scales than low hypnotisables (Semmens-Wheeler and Dienes, 2012).

We used a variation of Libet's experimental method to time the conscious awareness of an intentional action in high, medium, and low hypnotisable subjects, and in mindfulness meditators. Since cold control theory proposes that hypnotic responding relies on an ability to generate inaccurate HOTs of intending, it was predicted that the highly hypnotisable group would report an awareness of their intention as occurring later than other groups. On the basis that mindfulness meditation may lead to a tighter metacognitive coupling between first order intentions and their related HOTs, we predicted that mindfulness meditators would report an earlier W time than non-meditators.

Study 1

Method

Participants

Twelve long-term meditators with at least 3 years of meditation practice were recruited from Buddhist organisations in Brighton. One meditator was excluded as they reported an inability to read clocks. So, data from 11 meditators were analyzed (5 males, 6 females; mean age = 37.8, SD = 16.4) with a mean of 12.7 years of meditation experience (SD = 10.6) and a mean of 14.7 h per month meditation (SD = 11.3). Meditators were asked to provide details of their practice in simple terms and all reported using a form of mindfulness meditation.

Fifty-four undergraduate participants of varying hypnotisability were recruited from the University of Sussex hypnosis screening database. Eight reported prior experience of meditation and were excluded, so data from 7 highly hypnotisable (1 male, 6 females; mean age = 19.6, SD = 2.1), 19 low hypnotisable (19 females; mean age = 20.3, SD = 6.9), and 20 medium hypnotisable subjects (3 males, 17 females; mean age = 23.0, SD = 6.0) are reported. Using a standard test of hypnotisability (Waterloo-Stanford Group Scale of Hypnotic Suggestibility, Form C (WSGC; Bowers, 1993) participants categorised as highly hypnotisable scored 9 or above from a possible 12 (M = 9.29, SD = 0.50). Medium hypnotisable participants scored between 4 and 8 (M = 6.00, SD = 1.41) and low hypnotisable subjects scored 3 or below (M = 1.95, SD = 1.22).

Participants were recruited for the duration of one term, until there were no more responses. Bayesian analyses were used to assess sensitivity. As stopping was not conditional on a function of the *P*-value, orthodox statistics assuming fixed *N* could be used (Cox and Mayo, 2010, section 10.1). Crucially, we used Bayesian analyses to indicate the strength of evidence for H1 versus H0; the measure of evidence is valid no matter what the stopping rule.

Ethical approval was received from the University of Sussex ethics committee and informed consent was obtained from each participant before commencing with the study. Participants received cash payment of £5 or course credits.

Apparatus and materials

The apparatus, controlled by a Programmable Interface Controller (PIC) microcontroller, comprised two connected units: a clock (Fig. 1) an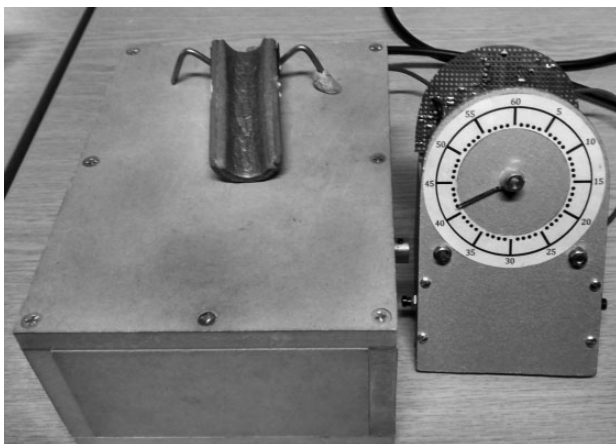d a switch assembly. The clock had a conventional face, but the hour labels (1, 2, 3…12) were replaced with minute labels (5, 10, 15…60). The clock's single hand was driven by a stepper motor, requiring 2400 steps to complete one revolution. The motor was pulsed every millisecond, thus one revolution took 2.40 s and the "minute" marks on the face represented increments of 40 ms. When participants reported values on the clock face, these were converted to the equivalent number of milliseconds from the 12 o'clock (60) mark. The clock was connected to a switch, the contacts being closed by a light metal sleeve, worn on the participant's finger. The sleeve was lined with soft foam, the arrangement being designed so that no tactile information was available to indicate whether the switch was closed or not; this could be deduced only via proprioceptive feedback. In the rest position, the finger, with its conducting sleeve, rested across the two contacts of the switch, completing the circuit. Raising the finger broke the circuit, and the time registered by the clock at that moment was recorded by the microcontroller with 1 ms resolution. The result was shown on a seven-segment display, oriented out of sight of the participant. The finger could be lifted voluntarily, but there was also a mechanism by which the experimenter could cause the finger to rise. This facility was not used in the experiments reported here.

All participants were asked to complete the dissociative experiences scale II (DES-II, Carlson and Putnam, 1993). One meditator did not complete the DES-II.

Procedure

The experiment was adapted from Libet *et al.* (1983). Subjects carried out 5 practice trials and 40 test trials (2 blocks of 20 trials with a 5-min rest period). Participants were asked to rest their finger upon the switch assembly to complete the circuit, then to wait for one full revolution of the clock hand before lifting their finger at a time of their choosing. They were asked not to plan ahead or to aim for a particular time. After raising their finger, they were asked to replace their finger and then to report the time indicated by the clock at which they had first experienced their immediate intention to move (a W judgement). They were instructed to make full use of the clock face in reporting (rather than rounding the time on the clock to the nearest five unit marker). The time at which the circuit was broken was recorded, together with the stated clock time.

Analysis

Finger-lift times (in milliseconds) were subtracted from the subjective report of the timing of immediate intention (converted to milliseconds) to give a numerical value for the difference between the timing of the reported intention and the moment at which the circuit was broken (W). Time differences on individual trials with values greater than 3 SD from the mean were excluded for each participant (21 trials in total, 0.9% of all trials). Mean scores for time difference were taken for each group and, following convention, a negative number was used to denote that the awareness of intention occurred before the circuit was broken and a positive number that it occurred afterward.

The interquartile range of judgement errors was compared between groups to assess whether there were differences in attention to the task. Mean DES-II scores were calculated for group comparison and correlation analysis.

Bayes factors (*B*) were used to assess strength of evidence (cf. Wagenmakers *et al.*, in press). A *B* of above 3 indicates substantial evidence for the alternative hypothesis and below 1/3 substantial evidence for the null. *B*'s between 3 and 1/3 indicates data insensitivity (see Jeffreys, 1939; Dienes, 2014). In order to indicate how strongly evidence supports a hypothesis, one has

Figure 1. The clock apparatus.

to specify what the hypothesis predicts; that is, for H1, one needs to specify roughly the sort of effect predicted, as for example based on a relevant past study. Williams *et al.* (2011) found a difference of 230 ms in W timing between functional motor disorder patients and a control group. It has been proposed that such functional disorders rely on the same mechanisms as hypnotic response (Bell *et al.*, 2011), so the effect is relevant. Assuming 230 ms is a rough maximum effect we could expect given it was found comparing a clinical population to controls, Bayes factors for W timing group differences were calculated using a half-normal distribution with $SD = 115$ ms. Although here we interpret the results with respect to Bayes Factors, P values are also provided for each analysis.

Bayes factors for correlations of hypnotisability with other measures were calculated using a half-normal distribution with $SD = 0.30$ based on the moderate correlations reported between hypnotisability scores and other cognitive or questionnaire-based measures (e.g., Laurence *et al.*, 2008). As directional predictions were not made for correlations between hypnotisability and gender or age, the Bayes factors for these correlations were calculated using a full-normal. Here, $B_{H(0, x)}$ refers to a Bayes factor where H1 is specified as a half-normal distribution with a SD of x (for directional predictions), and $B_{N(0, x)}$ indicates H1 was specified as a normal distribution with mean 0 and SD x (for non-directional predictions). Bayes factors and t-tests were corrected for unequal variance by the procedure of Box and Tiao (1972, p. 107) for adjusting standard errors and degrees of freedom.

The 3-df effect of group was decomposed into three contrasts. Specifically, the effect of hypnotisability was evaluated in terms of a linear trend (highs versus lows) and a quadratic trend (mediums versus the average of highs and lows). Finally, meditators were contrasted with mediums because the relative numbers of participants in each hypnotisable group do not reflect their proportions in the population (approximately 10% of the population are high and 10% low hypnotisable by conventional thresholds). The B's for these three contrasts were multiplied together to obtain an "omnibus B" evaluating the predictions of cold control versus H0. Support for cold control was taken as being shown by evidence: for a linear trend of hypnotisability versus H0; for H0 versus a quadratic trend; and for a difference between meditators and mediums versus H0. The resulting omnibus B assumes that the B for each contrast tests predictions independently of the other contrasts in the precise sense that the effect size tested in each contrast would not be relevant to updating the predicted effect size for the other contrasts (Jeffreys, 1939, pp. 269–70). We include omnibus B only for completeness so that wherever we give a P-value we also give a B, but in fact no conclusions will depend on omnibus B's in any case.

Bayes factors for DES-II analysis were calculated with a full normal based on half the difference between highs and lows (24 points) reported in Terhune *et al.* (2011).

H1 for interquartile range analysis was specified using a uniform from zero to the medium hypnotisable groups' interquartile range, specified as $B_{U[0,m]}$, where m is the maximum of the uniform distribution. The interquartile range can be normalised with a log transform, which also provides a "data translated" likelihood especially suitable for Bayesian analyses when a uniform is used to specify predictions (Box and Tiao, 1972).

A Bayes factor for age difference between meditators and mediums was calculated using a half-normal based on the minimum number of years of meditation experience (3 years) used as a criterion for selection.

Results

We will first consider the key predictions regarding the timing of awareness of intentions. Then we consider two more secondary issues: any role of dissociative experiences as measured by DES-II; and finally any differences in sustaining attention on the task, as measured by the consistency of the W response.

Figure 2 shows mean time differences and confidence intervals for the four groups. A Welch one-way ANOVA on the time differences (W timings) between the four groups indicated that the groups differed, $F(3, 24.63) = 16.54$, $P < 0.001$, omnibus $B_{H(0, 115)} = 2570.41$. There was a linear trend of hypnotisability on W judgements, $t(22.76) = 3.84$, $P = 0.003$, $d = 1.22$, $B_{N(0, 115)} = 92.01$. There was no quadratic trend, $t(44) = 0.042$, $P = 0.966$, $d = 0.013$, $B_{N(0, 115)} = 0.23$. Finally, meditators reported earlier W judgements than mediums, $t(28.78) = 3.04$, $P = 0.007$, $d = 0.95$, $B_{N(0, 115)} = 22.27$. Pearson's coefficient was used to test for correlations. A correlation between WSGC (hypnotisability) score and W was found, $r(47) = 0.30$, $P = 0.043$, $B_{H(0, 0.30)} = 5.43$.

There was evidence that the mean age of meditators (M = 37.8, SD = 16.4) differed from medium hypnotisables (M = 23.0, SD = 6.9, $t(12.0) = 2.87$, $P = 0.014$, $B_{H(0, 3)} = 2.98$. The evidence was not sensitive as to whether or not there was a within-group correlation between age and W judgements, (Fisher z-transformed) $r(57) = -0.069$ (SE = 0.13) $B_{N(0, 0.30)} = 0.45$. But crucially, a one-way Analysis of covariance (ANCOVA) showed that, after accounting for age, mean W differed between meditators (M = −149.1 ms, SE = 29.3) and medium hypnotisable non-meditators (M = −68.5, SE = 20.6), $F(1,28) = 4.36$, $P = .046$, $B_{H(0, 115)} = 4.40$.

Turning now to dissociative experiences, the evidence was insensitive as to whether or not there was a correlation between W and DES-II score, $r(56) = 0.015$, $P = 0.911$, $B_{H(0, 0.30)} = 0.44$. DES-II and WSGC scores correlated, $r(49) = 0.473$, $P = 0.001$, $B_{H(0, 0.30)} = 79.45$. A contrast between highs (M = 31.22, SD = 15.59) and lows (M = 14.3, SD = 7.7) revealed a linear trend of hypnotisability on DES-II scores, $t(7.09) = 2.75$, $P = 0.028$, $d = 0.57$, $B_{H(0, 12)} = 3.95$, and there was no evidence one way or the other for a quadratic trend, $t(44) = 0.497$, $P = 0.621$, $B_{N(0, 12)} = .47$. Meditators (M = 11.5, SD = 9.8) differed from mediums (M = 20.8, SD = 3.1), $t(23.4) = 2.18$, $P = 0.040$, $d = 0.88$, $B_{H(0, 12)} = 4.70$.

Finally, we consider group differences in sustaining attention to the task, as measured by consistency of response; specifically, a participant's interquartile range in their W responses. There was no linear trend of hypnotisability on inter-quartile range (highs M = 143.2 ms, SD = 52.2; vs. lows, M = 131.9 ms, SD = 46.7) revealed by a t-test conducted on log-transformed values, $t(24) = 0.627$, $P > 0.250$, $d = 0.29$, $B_{U[0, 2.17]} = 0.07$. Meditators (M = 123.0 ms, SD = 40.22) and mediums (M = 168.2 ms, SD = 104.6) did not differ in interquartile range. $t(29) = 1.48$, $P = .149$, $d = 0.56$, $B_{U[0, 2.17]} = 0.23$.

Study 1 discussion

The key findings of Study 1 are that highs show an especially late awareness of intentions, consistent with cold control theory. Conversely, meditators show an especially early awareness of intentions, consistent with meditation experience inducing metacognitive changes. We found that these differences did not arise from attentional differences between groups, and therefore they may be purely metacognitive.

Dissociation has been found to interact with hypnotisability in executive related tasks (e.g., Terhune *et al.*, 2011). Thus, our conclusions about the relation between high hypnotisability and W judgments may apply only to the subgroup of highs identified by Terhune *et al.* as high-dissociating highs. While
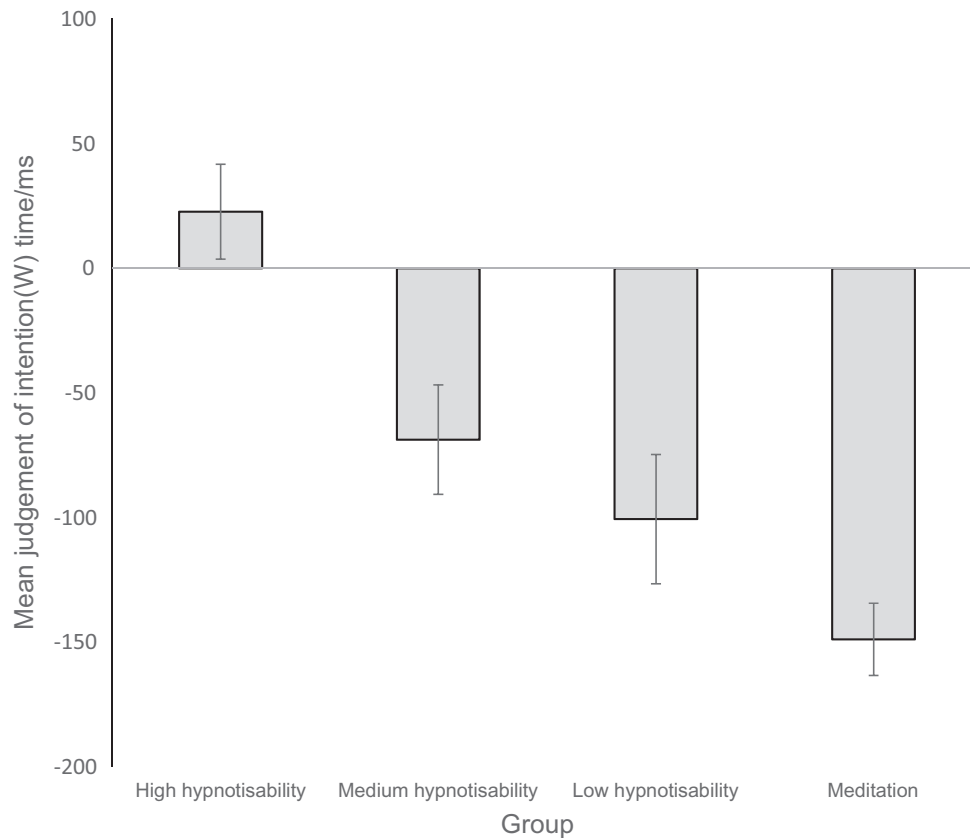
Figure 2. Mean time differences between the retrospectively self-reported time at which a volitional immediate intention to perform a motor action was experienced and the moment at which the movement occurred. Error bars show 95% CIs (the CIs can be treated as credibility intervals with uniform priors).

the high DES-II scores of highs in Study 1 prevented investigation of this possibility, further research could usefully select low dissociating highs and lows and determine if the pattern still holds. The association we found between DES and hypnotisability contradicts the null finding by Dienes *et al*. (2009); however, the latter study tested hypnotisability and the DES in entirely unrelated contexts, conditions known to reduce correlations of variables with hypnotisability (Kirsch and Council, 1992). When hypnotisability and DES are tested in the same context, people may interpret the questions of the DES as asking about hypnotic experiences. A possible weakness of the study is that we do not know the hypnotisability of participants in the meditation group. Studies 2 and 3 will assess mindfulness in participant groups in which hypnotisability is known.

Study 2

Introduction

Study 2 was a conceptual replication of Study 1 measuring mindfulness with a standard questionnaire in undergraduates rather than by contrasting meditators with non-meditators and investigated whether the early W judgements reported by mindfulness meditators also occur in meditation naïve participants high in trait mindfulness. As hypnotisability was measured on all participants, this study examined the relationship between mindfulness and the timing of an intention to move in groups of known hypnotisability. The study also investigated the relationship between hypnotisability and trait mindfulness.

Buddhist traditions suggest that long-term meditation leads to the development of mindfulness skills in everyday life, and experienced meditators have been shown to score higher on the Five Facet Mindfulness Questionnaire (FFMQ) than non-meditators (Baer *et al*., 2008). Therefore, we might not expect meditation-naive participants high in trait mindfulness to display mindfulness related metacognitive abilities to quite the same degree as experienced meditators.

Method

Participants

Thirty-six meditation-naïve undergraduate students were recruited from the University of Sussex. Following initial examination of the data, two participants were excluded from further analysis as their scores for mean W judgement identified them as outliers by SPSS boxplot. Data from 34 participants were therefore analyzed.

Ethical approval was received from the University of Sussex ethical committee and informed consent was obtained from each participant before commencing with the study. Participants were compensated with course credits.

Materials and methods

Participants were screened for hypnotisability using an edited version of the WSGC. This involved a shortened induction and the delivery of one of two selections of five suggestions taken from the WSGC scale. Each set of suggestions contained one motor direct suggestion, two perceptual direct suggestions, one

motor challenge suggestion, and one perceptual–cognitive challenge suggestion. Participants were randomly assigned to either set of suggestions. Unlike in the WSGC:C, in which participants are screened as a group and, therefore, report their own objective ratings, because the screening sessions were individual, it was possible for objective ratings to be taken by the experimenter. The WSGC:C does not include subjective ratings and here a further subjective rating was recorded from the participant's verbal answers to a set of standard questions (see Supplemental Material for the hypnosis scripts and scoring procedure). W timing was measured using the same apparatus and procedures as in Study 1.

Participants also completed a short form of the FFMQ, a 24-item questionnaire which measures 5 different facets of mindfulness; observing, describing, acting with awareness, non-judging, and non-reactivity (FFMQ-SF; Bohlmeijer *et al.*, 2011).

Participants were recruited for the duration of one term, until there were no more responses. Bayesian analyses were used to assess sensitivity.

Analysis

Mean judgement errors on the Libet clock task were calculated for each participant as in Study 1. Mean ratings of objective and subjective scores for hypnotisability and scores on the FFMQ-SF were calculated. A combined hypnotisability measure was calculated from the objective and subjective hypnotisability ratings. Both the objective and subjective ratings were measured on a scale of 0–5; the combined measure was the simple average of the subjective and objective measures. Results for the individual hypnotisability ratings are presented in the Supplementary Materials.

Bayes factors were calculated as in Study 1. A B was calculated for the correlation between objective and subjective hypnosis scores using a full-normal with SD = 0.82 (converted to Fisher's Z) based on the average correlation between objective and subjective hypnotisability ratings across three screening procedures reported by Barnes *et al.* (2009).

Results

Subjective (M = 2.0, SD = 0.8) and objective (M = 2.0, SD = 1.4) hypnosis ratings correlated, $r(34) = 0.69$, $P < 0.001$, $B_{H(0, 0.82)} = 16439.52$, The combined measure of subjective and objective hypnotisability (M = 2.1, SD = 1.0) correlated with W judgement, (M = −75.0 ms, SD = 84.5 ms), $r(34) = 0.321$, $P = 0.065$, $B_{H(0, 0.30)} = 3.76$, and negatively correlated with FFMQ-SF score, $r(34) = −0.403$, $P = 0.018$, $B_{H(0, 0.30)} = 9.39$.

Study 2 discussion

These results support the relationship between hypnotisability and judgement of intention reported in Study 1 and are consistent with evidence that hypnotisability is inversely related to trait mindfulness. However, as there was no sensitive evidence for a correlation between trait mindfulness and W judgements, no conclusion can be drawn as to whether trait mindfulness is related to metacognition of motor intentions.

Study 3

Introduction

Study 3 replicated Study 2 but differed in two aspects. First, a computer clock was used. Second, unlike in the first two studies, M judgements (the timing of action) were taken alongside W judgements. Libet considered the M judgement an important part of participant training, and found that when M trials were performed before W trials, W times were significantly more negative (Libet, 1983). However, the use of M judgements to influence identification of the moment of intention has been criticised (Gomes, 1998), and Pockett and Miller (2007) argue that subjects in subjective timing experiments should be kept as naïve as possible. The −75 ms timing of W reported here in the absence of an M judgement is later than the −200 ms mean W time and close to the −85 ms mean M reported by Libet *et al.* (1983). This might be interpreted as evidence that subjects in these studies misunderstood the request for a W judgement and gave M judgements instead. Study 3 investigated whether the relation between hypnotisability and W would hold when M as well as W judgments are taken.

Method

Participants

Twenty-nine meditation-naïve undergraduate students were recruited from the University of Sussex. One participant was excluded prior to analysis due to equipment malfunction. Ethical approval was received from the University of Sussex ethical committee and informed consent was obtained from each participant before commencing with the study.

Materials and methods

Participants were screened for hypnotisability using the same procedure as in Study 2.

Visual stimuli were displayed at 100 Hz on a 21" CRT monitor. At the beginning of each trial, a clock face was presented. This was marked at 30° intervals and subtended a visual angle of 5°. A static dot, subtending at 0.2° appeared at a pseudo-randomised position for each trial and began rotating around the clock face 250 ms after the clock appeared, performing a full rotation every 2560 ms. Participants were seated at a viewing distance of approximately 60 cm. A computer mouse was used to record actions (button presses).

Participants were asked to press the mouse button at a time of their choosing and to report either the time of the action (M) or the time of their immediate intention or urge to move (W). In both trial types, participants were instructed to allow the dot to complete at least one full revolution before pressing the mouse button. If this instruction was not followed, a warning message was displayed and the trial restarted. Similarly, a warning message was displayed and the trial restarted if the button had not been pressed within six full rotations of the clock.

Participants were asked not to preplan their actions. After the button had been pressed, the clock continued moving for a pseudo-randomised period of time between 1200 ms and 2370 ms to prevent any influence from the sudden disappearance of the dot. There then followed a pseudo-randomised time interval (500–1280 ms) during which the clock was not visible on the screen. Timing judgements were then recorded by moving a dot around the clock face and pressing the mouse button.

Each block consisted of 40 repetitions of one trial type and blocks were separated by 30-s rest periods. The two blocks were presented in counterbalanced order. All Stimuli were programmed by Jim Parkinson (University of Sussex) and generated with Matlab (MATLAB 2012b, The MathWorks, Inc., Natick, MA, USA) running Psychtoolbox v3 (Kleiner *et al.*, 2007).

Participants also completed a short form of the five facet mindfulness scale questionnaire (Bohlmeijer *et al.*, 2011), as in Study 2. Two participants failed to complete the questionnaire.

These participants were included in all analyses except correlations with the FFMQ-SF.

Participants were recruited for the duration of one term, until there were no more responses. Bayesian analyses were used to assess sensitivity.

Analysis

Mean judgement errors on the Libet clock task were calculated for each participant as in Study 1, but for M (timing of movement) as well as W judgements.

Mean ratings of objective and subjective scores for hypnotisability and scores on the FFMQ-SF were also taken. A combined hypnotisability score was calculated as in Study 2. Results for the individual hypnotisability ratings are presented in the Supplementary Materials. The distance between M and W was also calculated for each participant (M/W distance).

Results

M judgements (M = −17.1 ms, SD = 40.1) correlated with W judgements (M = −143.7 ms, SD = 159.0), Spearman's ρ (28) = 0.526, P = 0.004, $B_{H(0, 0.50)}$ = 44.61. Objective (M = 1.6, SD = 1.2) and subjective (M = 1.7, SD = 1.0) hypnosis ratings were correlated, Spearman's ρ (28) = 0.690, P < 0.001, $B_{H(0, 0.30)}$ = 1307.98. The combined hypnotisability rating (M = 1.6, SD = 1.0), and the derived measure of the distance between M and W were correlated, Spearman's ρ (28) = −0.376, P = 0.049, $B_{H(0, 0.30)}$ = 4.90. The combined hypnotisability measure correlated with W, Spearman's ρ(28) = 0.350, P = .068, $B_{H(0, 0.30)}$ = 3.85. There was no evidence as to whether or not M judgements correlated with the combined hypnotisability measure, Spearman's ρ(28) = 0.161, P = 0.414, $B_{H(0, 0.30)}$ = 1.06.

The evidence was not sensitive as to whether or not FFMQ-SF scores correlated with W, Spearman's ρ (26) = −0.136, P > 0.250, $B_{H(0, 0.50)}$ = 0.67, or with the combined hypnotisability score, Spearman's ρ (26) = −0.147, P > 0.250, $B_{H(0, 0.30)}$ = 0.98.

Table 1 shows the results of a fixed-effects meta-analysis conducted on the results of Studies 2 and 3 to test the overall evidence for correlations. This revealed support for correlations between hypnotisability and W judgement and hypnotisability and mindfulness. The Bayes factor on FFMQ-SF score versus W was insensitive, so no conclusion follows.

Study 3 discussion

Consistent with predictions, there was evidence that the distance between M and W judgements was inversely related to hypnotisability. This counts against the suggestion that highly hypnotisable people may have confused W with M judgements. The evidence for a relationship between trait mindfulness and hypnotisability was inconclusive in this study, but a meta-analysis of Studies 2 and 3 provides support for this relationship. Strong support is also provided for a relationship between hypnotisability and judgement of time of intention across the studies. We were unable to provide any evidence one way or the other for the relation between trait mindfulness and W judgments. Thus, the question of whether meditation practice per se as a training in metacognitive awareness of intentions, rather than trait mindfulness, is crucial to early W judgments remains open.

General Discussion

We used the Libet task to investigate group differences in the timing of the conscious awareness of an action intention (W) in hypnotisable groups and mindfulness meditators. A linear effect of hypnotisability was found on W (cf. Kirsch, 2011), with highly hypnotisable participants reporting a later W time than less hypnotisable participants. Conversely, mindfulness meditators reported an earlier W time than non-meditators. These differences are supported by a positive correlation between hypnotisability and W timing in two further studies and a negative correlation between hypnotisability and trait mindfulness in a meta-analysis of the results of Studies 2 and 3. The results are consistent with the prediction from cold control theory that hypnotisability is inversely related to the coupling of higher order thoughts to first-order intentions; that is, most generally, with theories of hypnosis that argue that hypnotic responding involves changes in the monitoring of intentions, rather than changes in executive control. Furthermore, the earlier W timing reported by experienced meditators supports predictions from Buddhist scholars (Dreyfus, 2013) that mindfulness meditation enhances metacognition related to action intentions.

Notably, we have recently found that there is no difference in M judgements between hypnotisable groups and no difference in M between meditators and non-meditators. A fixed-effects meta-analysis was conducted on M judgement differences in meditators reported in Lush *et al.* (submitted for publication) and in Semmens-Wheeler (2012). Mean difference = 6.6 ms, P = 0.806 [−46.4, 59.7], $B_{H(0, 0.80)}$ = 0.27. This B supports there being no difference between meditators and non-meditators in M judgements. However, we report here that W judgements do differ between these groups. As we found evidence for no differences in interquartile range, these results are unlikely to be attributable to differences in attention to the task.

Table 1. Meta-analytically combined Fisher z-transformed Pearson and Spearman's correlations between measures of hypnotisability, mindfulness, and timing of intention (W) in Studies 2 and 3

	Measure			
	Overall hypnotisability	Subjective hypnotisability	Objective hypnotisability	Mindfulness (FFMQ-SF)
W judgement	0.347 (0.129)	0.369 (0.129)	0.270 (0.129)	−0.19 (0.131)
	P = 0.009	P = 0.005	P = .041	P = 0.152
	[0.094, 0.600]	[0.117, 0.622]	[0.018, 0.523]	[−0.067, 0.447]
	$B_{H(0, .30)}$ = 16.63*	$B_{H(0, 0.30)}$ = 24.85*	$B_{H(0, 0.30)}$ = 4.88*	$B_{H(0, .30)}$ = 1.76
Mindfulness (FFMQ-SF)	−0.306 (0.131)	−0.373 (0.131)	−0.203 (0.131)	
	P = 0.023	P = 0.006	P = 0.126	
	[−0.049, −0.564]	[−0.115, −0.630]	[−0.055, −0.460]	
	$B_{H(0, 0.30)}$ = 7.79*	$B_{H(0, 0.30)}$ = 23.98*	$B_{H(0, 0.30)}$ = 2.03	

Note: Standard deviations appear in parentheses after means. 95% CI and Bayes factors are reported below means. * = sensitive B (evidence for the hypothesis).

Jo *et al.* (2015) reported no significant difference in W judgements between meditators and non-meditators, but with means showing large effects in the same direction as we found here. A fixed-effect meta-analysis of the standard Libet instruction comparison reported in Jo *et al.* and Study 1 revealed strong evidence in favor of an earlier W time in meditators rather than non-meditators (M = 76 ms, SD = 24.2), $B_{H(0, 115)} = 46.25$.

Historically, there has been little agreement as to what the Libet task is measuring (e.g., Dennett and Kinsbourne, 1992; Maoz *et al.*, 2014), and these results may inform that debate. One possible interpretation is that the findings may reflect differences in a threshold or criterion level of the brain activity underlying voluntary movement at which people can become conscious of an intention to move (cf. Schurger *et al.*, 2012). On this reading, highly hypnotisable people may have a higher threshold (perhaps resulting from coarser grained concepts of first-order intentional states) and thus take longer to become aware of intending. Conversely, mindfulness practice may lower this threshold (perhaps due to the development of finer grained concepts of mental state properties). Alternatively, it has been argued that consciousness is graded and that the timing of awareness of action intentions may instead reflect a threshold of reportability (Miller and Schwarz, 2014; though contrast Dehaene *et al.* 2014, for the argument that consciousness is relatively all-or-none). These findings are consistent with either interpretation. From a higher order theory perspective (e.g., Rosenthal, 2005), whatever pressure brings about possession of concepts of mental states, would not need make such higher order states more fine-grained in content than the gradations of first-order states themselves. Thus, higher order states will likely make discrete distinctions between first-order states (for evidence concerning the extent to which confidence ratings, i.e. higher order thoughts, reflect discrete states, see Swagman *et al.*, 2015). Thus, awareness of first-order states (specifically intentions) may be discrete to a degree that varies across individuals (e.g., between high and low hypnotisable individuals) and that can be made more fine grained by practice (e.g., mindfulness meditation). Notably, Schlegel *et al.* (2015) report motor cortex activity associated with intentional action for highs performing actions experienced as involuntary following a post-hypnotic suggestion, consistent with there being no change in first-order processes in hypnotic responding.

The related question of how one becomes aware of an intention has been the focus of a large body of research in recent years (e.g., Haggard and Eitam, 2015), with competing accounts proposing retrospective (e.g., Wegner, 2002) or predictive (e.g., Blakemore *et al.*, 2002) cues. Current theoretical models propose that the sense of agency is supported by both predictive and retrospective mechanisms (Synofzik *et al.*, 2008), with the relative weighting of each depending up their reliability (so that signals of low noise have a greater influence) (Moore and Fletcher, 2012; Synofzik *et al.* 2013). However, this question is largely orthogonal to the hypotheses addressed here.

Recent findings suggest a second possible mechanism underlying the earlier W judgement timing reported by mindfulness meditators. Mindfulness involves not taking the content of mental states at face value, and thus potentially not being drawn to attractive or salient stimuli (e.g., Papies *et al.*, 2015). Possibly meditators in estimating the time of an intention is thus not unduly drawn to the time of the action, allowing an earlier estimate of the time of the intention. However, contradicting this explanation, we have found that meditators compared to non-meditators show more intentional binding, that is,

a process by which the estimated time of one event is drawn toward that of another in an illusory way (Lush *et al.*, submitted).

Group differences in the timing of conscious awareness of intending a voluntary action may provide a route toward exploring related cognitive and neuronal processes. For example, Moore and Bravin (2015) report that increased variability of W judgement predicts high schizotypy scores (although there is evidence for a relationship between schizotypy and hypnotisability (e.g., Connors *et al.*, 2014), we found no difference in W variability between hypnotisable groups). Delays in the timing of W have also been reported in groups with parietal lobe damage (Sirigu *et al.*, 2003), and exploration of the neural processes and architecture supporting the differences reported here may provide further insight into disorders related to the awareness of intention, such as schizophrenia (for a review of disorders of volition, see Kranick and Hallett, 2013). Intriguingly, later W timing has also been found in conversion disorder patients (Edwards *et al.*, 2012), suggesting the possibility that cold control theory may provide a way of investigating the often hypothesised link between functional or psychogenic disorders and hypnosis (see Vuilleumier, 2014).

It has been argued that in order to become tractable to empirical investigation, consciousness may need to be theoretically divided into constituent structural properties (Seth, 2009). Phenomena that involve changes in subjective visual perception such as binocular rivalry has been employed to study neural correlates of visual consciousness (e.g., see Maier *et al.*, 2012). Similarly, the identification of hypnotic responding as changes in the subjective experience of intending may provide a fruitful avenue to investigate the biological substrates of conscious experiences of volition. More generally, the sense of agency is a rapidly growing field of study within psychology (see Moore and Obhi, 2012; Chambon *et al.*, 2014; David *et al.*, 2015; Haggard and Eitam, 2015), and the investigation of changes in the sense of agency resulting from hypnosis has the potential to illuminate and inform findings in this area.

In summary, this study reveals individual differences in the timing of a metacognition of action initiation related to mindfulness meditation and hypnotisability. These findings are consistent with the cold control theory of hypnosis and with the proposal that hypnotisability and mindfulness meditation lie at opposite ends of a scale of metacognition related to the conscious awareness of intention (Semmens-Wheeler and Dienes, 2012).

Data Availability Statement

Data available at Open Science Framework 68c2v (https://osf.io/68c2v/).

Acknowledgments

Supplementary Data

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