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THE PRODUCTION OF HYPNOTIC TIME-DISTORTION: DETERMINING THE NECESSARY CONDITIONS

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Abstract

An attempt was made to find the components of the hypnotic experience that give rise to familiar time-distortion effects. A series of experiments is described that examined a variety of hypnosis and hypnosis-like situations, known or expected to induce errors of time judgement. It was found that, if participants closed their eyes and imagined vividly, even in the absence of an induction or any reference to hypnosis, hypnotic-like time effects could be achieved. The results are interpreted in terms of the model proposed by Naish (2001), in which it is suggested that an internal clock runs more slowly when a person becomes detached from reality and generates his or her own experiences.

Key words: consciousness, detachment, eye closure, hypnosis, imagination, time judgement

Introduction

If, at the end of a 20-minute session of hypnosis, people are asked how long they thought it had lasted, the estimate is often as short as ten minutes. Although this shortening of retrospective time judgements in hypnosis is a very robust effect, the exact mechanisms that give rise to the error remain unclear. Indeed, St Jean (1988) pointed out that it had not, at that time, been established that the effect was attributable to hypnosis. It is, after all, a common observation that 'time flies' when one is engrossed in an activity and, although some activities (such as being absorbed in a book) may have elements apparently in common with hypnosis, many other tasks do not, so the effect may be better attributed simply to a general increase in the use of mental resources. This type of time distortion, resulting from cognitive workload, has been discussed by Zakay (1989). St Jean, McInnis, Campbell-Mayne and Swainson (1994) noted the similarity between the effect in hypnosis and the effect when occupied, and developed what they termed the 'Busy Beaver' hypothesis. This postulates that hypnosis is itself an activity that demands concentration (increased cognitive workload) and, as a result, gives rise to the usual temporal effects. If the hypothesis were true it could be interpreted as showing that time distortion is *not* in any specific sense caused by hypnosis. Of course the activity of being a participant in hypnosis causes time to fly, but to attribute that to the hypnosis *per se* would be as inappropriate as claiming that other activities, such as writing a research paper say, have specific time-distortion powers.

Naish (2001) pointed out that the pattern of time distortion across different tasks, revealed in the St Jean et al. (1994) data, implied that hypnosis was not in fact acting as an additional, concentration-demanding activity. In other words, although hypnosis

distorts time judgements, in the St Jean et al. study it appeared not to be doing so for the same reasons that some other tasks do. Perhaps, after all, hypnosis does have a specific influence upon time-estimation processes. This suggestion was supported by results reported by Naish (2001); it was shown that similar underestimation of duration occurred even for very brief time periods. Participants were asked to estimate the lengths of short tone bursts (mean duration five seconds), and were found to produce shorter estimates when making the judgement during hypnosis. Whereas the duration judgement of an entire session of hypnosis might plausibly be affected by the cognitive demands of the occasion, it was considered that a brief 'beep' estimation task would gain full access to the attentional resources. If, under these circumstances, time distortion persisted, then the effect might well be attributed to some change brought about by hypnosis.

In general, there has been little success in identifying effects that are attributable to special hypnotic processes. Frequently, candidate effects have been shown to be explicable in terms of the participants' willingness to comply with the task demands implicit in the situation (for example, Spanos, 1986). The transparency of these demands is easily demonstrated using the simulator paradigm (Orne, 1979); non-hypnotized participants are told to act as if hypnotized but, importantly, they are given no instruction as to how to do so. Nevertheless, the acted behaviour is more often than not indistinguishable (to a 'blind' researcher) from so-called genuine hypnosis. The implication must be that the demands of the situation were very clear; some theorists, of course, would go further and claim that the 'hypnotized' participants were also actually acting. Whether or not one accepts that stance, it remains the case that finding behavioural equivalence between real and simulating participants must weaken any claims for special hypnotic effects.

If it is to be claimed with any credibility that hypnosis has a special effect upon time estimation, then clearly the effects should be subjected to the simulator test. This has been done by Mozenter and Kurtz (1992), who showed that hypnotic time distortion is *not* an effect that can be simulated. The result should not be surprising, because it would be quite unclear to a naïve participant whether or not time judgements should change and, if so, in which direction. Mozenter and Kurtz (1992) also reported that hypnotized participants gave *overestimates* of prospective time judgements. The effect was explored more fully by Naish (2001), who (as for the retrospective judgement) included a brief-duration condition. This test required that a computer mouse button be held down for an estimated five seconds and, again, it was argued that, for such a brief period, attention would have been devoted to the task. Whereas retrospective judgements result in underestimates of the period assessed, the various forms of prospective judgement all resulted in overestimates when carried out during hypnosis.

Naish (2001) argued that the particular pattern of shortened and lengthened judgements was best explained by postulating the existence of an internal timing mechanism, which was caused to run more slowly during hypnosis. The explanation can be illustrated by imagining someone using a stopwatch to time runners in two different situations. In the first case, the situation is a race; the timekeeper does not know in advance how long the race will last and so uses the stopwatch to determine the time as a runner reaches the finish line. This is a retrospective measure. In the alternative situation the timekeeper himself or herself decides to run for, say, 20 minutes, and uses the watch to measure this predetermined duration. This is a prospective timing task. Suppose that the stopwatch has been caused to tick too slowly, for example at half the correct rate. In the retrospective situation, if the runner reached the finish in a true 20 minutes the watch would register only 10 minutes, so there would be an underestimate. In the second case, the

runner who intended to run until the watch registered 20 minutes would in fact have run for 40, producing an overestimate. These are analogues of the underestimates and overestimates found in hypnosis.

The slow-timer hypothesis for hypnotic time distortion makes two assumptions: first, that there is some form of internal clock that is used in timing tasks and, second, that the clock rate is susceptible to change. Both these assumptions appear to be correct, as has been demonstrated by Treisman and his colleagues (for example, Treisman, Faulkener, Naish and Brognan, 1990). However, although the clock may be influenced by some rather gross environmental factors, such as visual flicker (Droit-Volet and Wearden, 2002), loud click trains (Treisman, Faulkener and Naish, 1992), or elevations of body temperature (Fox, Bradbury, Hampton and Legg, 1967), it is not clear how hypnosis would exert any influence. Naish (2001) suggested that the effect may be mediated via the 'consciousness loop' proposed by Gray (1995). Gray's model proposes that the brain maintains a sample-and-predict cycle, which continually monitors the environment and directs attention to elements that do not match prediction. Naish (2001) suggested that the cycle rate was equivalent to the internal clock 'tick' rate. Moreover, he proposed that, because the environment of a participant in hypnosis changes only slowly (being largely self-generated), there would be less need for frequent sampling. As a result, the tick rate would tend to slow down. Clearly, this explanation of hypnotic time distortion is speculative, so there is a need to gather further data, which might support or refute the hypothesis.

It has often been pointed out that many of the elements of hypnotic behaviour are present in other situations that are not defined as hypnosis (for example, Fellows, 1986). In general, the non-hypnosis analogues share with hypnosis the characteristic of imaginative involvement; examples of this often cited are being 'lost' in a book, or identifying strongly with the characters in a film (Barber, Spanos and Chaves, 1974). It may prove informative to find and explore an example where time distortion has been recognized as an associated phenomenon. One such case has been reported (Mitchell and Davis, 1987); it involved the use of model environments. Prior to this study, it had been observed that people inspecting architects' models misjudged their inspection time (DeLong, 1981). Mitchell and Davis (1987) investigated the effect, by using model railway layouts. Participants were asked to keep inspecting a model, and to imagine that they were on the station platform, waiting for a train that was due in a specified number of minutes. They were required to indicate when they believed the time was up; thus, this was a prospective time estimation task. It would seem reasonable to suppose that imagining oneself to be part of a model scene is a very similar task to imagining a scene (so often a beach) in hypnosis. Both appear to be clear examples of imaginative involvement. The result, in hypnosis, has already been discussed: prospective judgements are lengthened. With the model railway, however, the judgement was shortened, as if the clock was ticking faster rather than slower. There was even some indication that the smaller the scale of the model, the faster the clock ticked, as if the tick length was also being scaled. This result is perplexing; in a situation that appears to have a great deal in common with hypnosis, the timing distortion was reversed. The first experiment to be reported here was an attempt at partial replication, prior to further investigation of the effect.

Experiment 1

It was intended that a series of studies would be conducted in different locations, so it was hoped that a photographic version of the model railway effect would be as effective

as a real model; photographs would be more portable and simpler to present. To test the viability of this approach, a series of photographs was taken of a model railway, and these were used to determine whether they would induce a shortening of prospective time judgements in a manner equivalent to that of Mitchell and Davis (1987).

Method

Four photographs were taken of an 'OO' scale (1/72) model railway. These comprised different views of the scene and included partial views (for example, face or hand) of the owner, thus emphasizing the scale of the model. One picture showed the station clearly, and included a (model) church tower in the background, complete with a clock, although it was not possible to discern the position of the hands on the clock. The photographs were reproduced on overhead projection acetates.

Participants were tested in groups of four. They were given stopwatches and sat at some distance from one another, so that their movements or sounds of operating the stopwatches would not be noticeable to others. Participants were told that they would be shown a series of model railway pictures, and that they were to imagine themselves waiting on the platform for a train. It was suggested that they should imagine doing just the sort of things they would normally do in those circumstances: walk up and down, look in the kiosk, check the time on the clock and so forth. Participants were asked to press the start buttons on their stopwatches when the experimenter said 'go' – and that, from that moment, the train was due in exactly five minutes. They were to press the stop button when they believed that the train was due; until that time they were to continue imagining themselves on the platform and, of course, not to look at the stopwatch. The pictures were then projected onto a large screen, showing the first three one at a time, for ten seconds each. The fourth picture gave a clear view of the station. When it was first displayed, participants were reminded to imagine themselves on the station platform, then they were told to start timing. The picture remained projected until all participants had responded with their five-minute estimates. At the end of the session comments were elicited from the participants.

Participants

Twelve volunteers were tested; they were psychology students, attending an Open University summer school. The course contained no information on the nature of time perception.

Results

Eleven of the 12 participants stopped their watches in less than five minutes. The mean duration of the five-minute judgements was three minutes 57 seconds (SD 66 seconds). This duration represented a reduction of 21.3% below the intended five minutes, a value that is of the same order as the 25.8% shortening reported by Mitchell and Davis (1987) in one of the conditions they tested. (The mean durations obtained in this and the following experiments can be compared in Figure 1.)

Discussion

The time distortion observed in this photographic version of the experiment was similar to that found by Mitchell and Davis (1987), who had used three-dimensional models. This result implies that a two-dimensional representation has a similar impact upon time estimation as viewing a physical model, but it does nothing to elucidate the mechanism for the effect. In particular, the results do not throw light on the question of why imagi-

native involvement of this sort should produce shortened judgements, while an apparently similar hypnotic situation produces lengthened estimates. Mitchell and Davis attributed their own findings to an impact of the scale and consequently the density of information in the scene; it was decided to test whether the scale of the depicted scene would have any effect on time judgements, when presented in photographic form.

Experiment 2

In the first experiment care was taken that the pictures presented would give a strong sense of being a scene that was much smaller than the viewer. To determine whether it was the smallness of scale that produced the time compression, in this experiment the pictures were chosen clearly to represent a large, full-scale landscape.

Method

Presentation in this experiment closely resembled the method used in experiment 1. The principal difference was that the four photographs were of mountain scenes, the last of which showed a small fishing port, with mountains across the bay and a fisherman working on nets. Participants were asked to imagine that they had spent time walking through the mountains, and were now going to wait by the sea, doing whatever felt appropriate, while awaiting a friend who was due in exactly five minutes. The presentation of the pictures and the instructions to start timing were all exactly as in the previous experiment.

Participants

Twelve Open University undergraduates were used. As before, they were attending summer school; they had not taken part in the first experiment and had no knowledge of timing effects.

Results

The mean duration of the five-minute estimate was three minutes 56 seconds (SD 110 seconds), which, it will be observed, is just one second shorter than in experiment 1. Ten of the participants underestimated the period.

Discussion

Clearly, the apparent size of the scenes depicted in the two experiments had no detectable impact upon time judgements. As the effect of scale was not a central issue in this study, the possible reasons for the differences between these findings and those of Mitchell and Davis (1987) will not be addressed further. However, it is very relevant to consider why the 'normal-scale' pictures elicited shortened time judgements. The invitation to imagine waiting on a beach appears to be very similar to the kind of suggestion often given in a hypnotic induction, a situation known to produce a lengthening of prospective time estimates (Naish, 2001).

There are a number of differences between picturing oneself in a photographed scene, and imagining being in such a situation following hypnotic induction, the most obvious difference being the induction itself. It has been three decades since Barber argued that an induction did no more than motivate participants to do what was expected of them (for example, Barber, 1969). This sceptical, non-state approach to hypnosis would seem to imply that embedding seaside imaginings within a hypnotic context should have no effect, unless it conveyed a clue as to what was expected. As stated in the introduction,

simulators do not display time distortion effects (Mozenter and Kurtz, 1992), so the situation seems not to be offering any cues of that sort. There must, therefore, be something intrinsic to the hypnosis that causes the temporal changes; moreover, whatever the cause, it is absent when simply imagining while viewing pictures. Naish (2001) argued that these timing effects justify a more state-like view of hypnosis. To be sure that hypnosis does, in all circumstances, behave as if slowing an internal clock, it was decided to add the hypnosis element to the picture-viewing technique already described.

Experiment 3

The intention in this experiment was to preserve the methods of the first two, as far as possible, while adding an hypnotic induction. In this way, it would be determined whether it was the absence of hypnosis that prevented the usual time slowing in the previous experiments, or whether it was an effect of the particular pictures used, or the means of displaying them.

Method

After the basic nature of the experiment had been explained, participants were informed that a simple hypnotic procedure would be used to help them in imagining the scene that they were to be shown. The sequence of pictures used was as in experiment 2: a series of mountain scenes, concluding with the beach view. Participants were given exactly the same instructions up to the point where they would have been asked to start their stopwatches. At this stage a standard hypnotic induction procedure was used involving progressive relaxation followed by guided visual imagery. The image described was the scene with the fisherman, which participants had just been viewing. They were not told what to imagine doing in the scene – merely to do whatever they wished, while waiting for the friend to arrive. At this point they were asked to start their stopwatches and begin timing. When all had concluded their timing, brief alerting instructions were given. All other aspects of the procedures were as in the previous experiments.

Participants

A further 12 students were used, who had not taken part in the earlier experiments and were naïve concerning time perception and the impact of hypnosis.

Results

The mean duration of the five-minute estimate was five minutes 36 seconds (SD 121 seconds). An analysis of variance showed this to be significantly longer than the estimates of experiments 1 and 2 ($F_{2, 33} = 3.78$, $p < 0.05$).

Discussion

It would appear that the addition of an element of hypnosis was sufficient to effect a significant lengthening of the time judgements. This invites enquiry as to what aspect of hypnosis achieved this result. Earlier, emphasis was placed upon the use of an induction, and of course an induction would be expected to precede the period of hypnosis. However, this does not mean that the induction procedures *per se* caused the time distortion. Indeed, it has been recognized for a long time (for example, Wagstaff, 1981) that simply to define a situation as ‘hypnosis’ may be sufficient to observe hypnotic effects. Rather than focus upon the demands implicit in an induction, it is appropriate to

consider the nature of the behaviour and experiences of the participants during the ensuing hypnosis phase and to examine how these might differ from those exhibited by non-hypnotized participants. In this context, it is pertinent to address the individual differences concealed in the mean times given in the three result sections above; not all participants in the 'fast' conditions (experiments 1 and 2) produced short response times, and not all in experiment 3 were slow.

In experiment 1 (mean judgement duration three minutes 57 seconds) the participant who took longer than five minutes (five minutes seven seconds) stopped viewing the final railway picture and shut his eyes, stating afterwards that this made it easier to imagine the scene. In experiment 2 (overall mean three minutes 56 seconds) two participants overestimated the period, with response times of five minutes 35 seconds and seven minutes 17 seconds. Both had shut their eyes; the first described visualizing sunbathing on the harbour arm (visible in the picture) and said that the experience was so realistic that the concrete felt hard. The second reported imagining paddling in the sea and said that she often visualized in that way as a form of relaxation.

In contrast to the over-long estimates described above, two participants in experiment 3 (overall mean five minutes 36 seconds) made much shorter responses (three minutes 53 seconds and three minutes 10 seconds). The first kept their eyes open throughout but claimed still to be visualizing vividly; the second had their eyes closed but reported being unable to visualize the scene at all. Taken together, the responses of the five atypical participants suggest that time lengthening occurs when two conditions apply: i) the eyes are shut, and ii) vivid visualization is taking place. These, of course, are likely elements of most hypnotic situations, probably following a traditional induction sequence.

Before exploring the above proposal, one other possible consequence of defining a situation as hypnosis should be considered. A situation so defined could be expected to produce a sense of relaxation (people anticipate becoming relaxed when hypnotized), and being very relaxed might plausibly have an impact upon time estimation. In fact this is probably not the explanation: Naish (2001) interpreted the results of a flicker-fusion test as showing that unusually deep relaxation was not a factor in the temporal effects of hypnosis. Thus, it remains unlikely that relaxation produced the timing effects in experiment 3, although, as detailed below, for certainty it would be eliminated from the procedures of experiment 4.

If not a result of relaxation, the temporal change may, as suggested above, have been brought about by the closing of eyes and engagement in visualization or it might have been caused by some other, as yet unknown element of hypnosis. A final experiment was undertaken, formally to test whether relaxation or an expectancy of hypnosis were necessary for traditional hypnotic timing effects to be displayed.

Experiment 4

This experiment was designed to preserve the pictorial elements of the first two, together with visualization and closed eyes, as achieved with most participants in experiment 3. However, the overtly 'hypnotic' components of that experiment were not used nor were any attempts to induce relaxation.

Method

The sequence of events was exactly the same as for experiment 2 but, just before participants were asked to start timing, they were requested to close their eyes and try to visualize the scene they had just viewed (the final beach scene) as vividly as possible. At

the conclusion of the timing period, participants were asked to rate the vividness of their visualizations on a seven-point scale, where 'one' represented complete failure to form any image, and 'seven' represented a very vivid experience, 'just like the real thing'. Similarly, participants were requested for a rating of how much intrusion they experienced from their actual surroundings. This score ranged from 'one' (completely unaware of surroundings) to 'seven' (very intrusive and distracting).

Participants

Twenty-four Open University summer-school students took part, these being a different group from those used in the earlier experiments.

Results

The mean duration of the attempted five-minute judgement was four minutes 49 seconds (SD 91 seconds). As the mean times in experiments 1 and 2 were effectively identical, the results of those two sets of 12 participants were combined and compared with the 24 participants of this experiment. This gave a total of 48 participants, half in an eyes-open and half in an eyes-closed condition. An unrelated *t*-test showed that the lengthening introduced by asking participants to close their eyes and visualize was significant: $t = 3.57$ (df = 46), $p = 0.001$. Although the time judgements were significantly longer in this experiment than in the first two, they were nevertheless shorter than in experiment 3, where hypnosis was used. To determine whether this difference was statistically significant, the estimates of the 12 participants in experiment 3 were compared with those of the 24 in this experiment, using the Mann–Whitney test. There was a significant difference: U = 193, U' = 95, $p = 0.05$.

The means of the ratings were as follows. Vividness: 5.4 (SD 1.0) and intrusion: 2.7 (SD 1.6). There was a correlation between these two scores: $r = -0.45$, $p < 0.05$. Thus

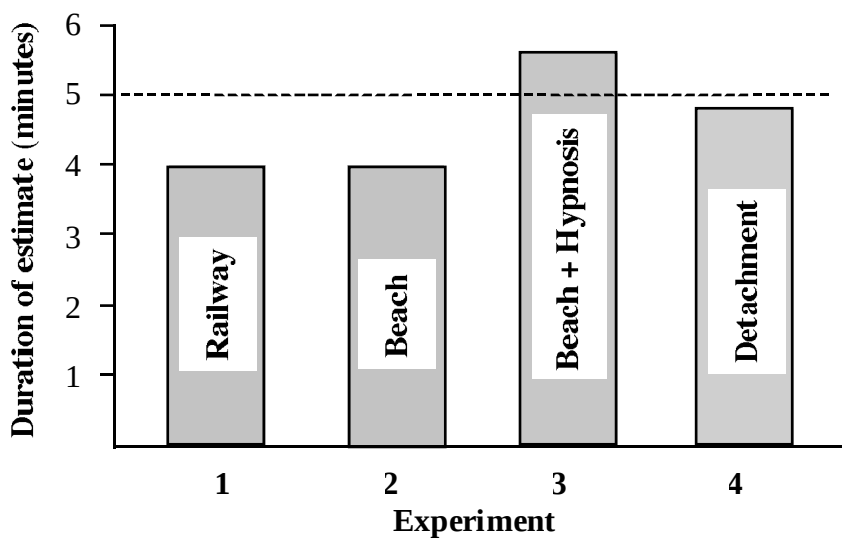

Figure 1. Mean durations of attempts to estimate a period of five minutes in each of the four experiments. Note: 'detachment' represents the condition of visualizing with eyes closed.

there was a tendency for those people who rated their visualization to be more vivid also to find their real surroundings to be less intrusive. Both of the ratings correlated with the duration of the time judgement. For vividness $r = 0.57$, $p < 0.005$, and for intrusion $r = -0.62$, $p < 0.001$. These values show a significant relationship between the two measures and the length of the time estimate, with greater vividness and lower intrusion being associated with longer judgement periods.

An estimate was made of how effectively each participant had become detached from external reality and generated a personal, internal reality. This estimate was expressed as a 'detachment' score, obtained by subtracting the intrusion rating from the vividness rating. As, in some cases, this resulted in a negative score, a constant, two, was added to each participant's score. Thus, detachment was given by:

detachment = vividness – intrusion + 2

The resultant scores ranged from zero to eight and they correlated with the time estimation values ($r = 0.75$, $p < 0.001$).

General discussion

The mean duration of a timing estimate observed in experiment 4 was significantly longer than that obtained in experiments 1 or 2, but shorter than that of experiment 3 (the comparisons can be seen in Figure 1). In other words, asking people to close their eyes and to try to visualize a scene appeared to make them behave as if their internal clocks were ticking more slowly, although not as slowly as when hypnosis was used. The difference from formal hypnosis can be accounted for in terms of the time spent in developing a detachment from external reality. For the hypnosis condition, in addition to the experimenter spending time describing the to-be-imagined scene, this was preceded by a period of progressive relaxation, in which participants were encouraged to focus attention upon internal sensations. This can be contrasted with the rather rapid, 'do-it-yourself' approach adopted in experiment 4, where, without preparation or further description, participants were simply instructed to close their eyes and start visualizing. The picture that emerges is that time distortion of the kind exhibited in hypnosis is a result of detachment from reality and the generation of an alternative 'inner world'. Hypnosis fosters this mental state more effectively than merely asking people to close their eyes and visualize; consequently, hypnosis produces larger time distortion. In support of this conclusion, in the last experiment, where hypnosis was not used, people nevertheless produced large positive timing errors when they also had large detachment scores. Conversely, those who scored low on detachment produced considerable underestimates in their attempts to produce a five-minute period. The detachment/timing relationship is shown in Figure 2.

This series of experiments has demonstrated rather clearly that the switch from what might be termed an external world to an internal world is likely to be the key time-distorting component of hypnosis. This is not a switch that is unique to hypnosis (it would seem, for example, to be a major component of day dreaming) but it is normally a central element of any traditional induction procedure. It was explained in the introduction that time distortion has a special status among behavioural effects of hypnosis, because it is possibly unique in not being exhibited by simulators; it could be called a 'true indicator' of hypnosis. If that is a reasonable description then the causes of time distortion might be seen as the 'true processes' of hypnosis – what Orne (1959)

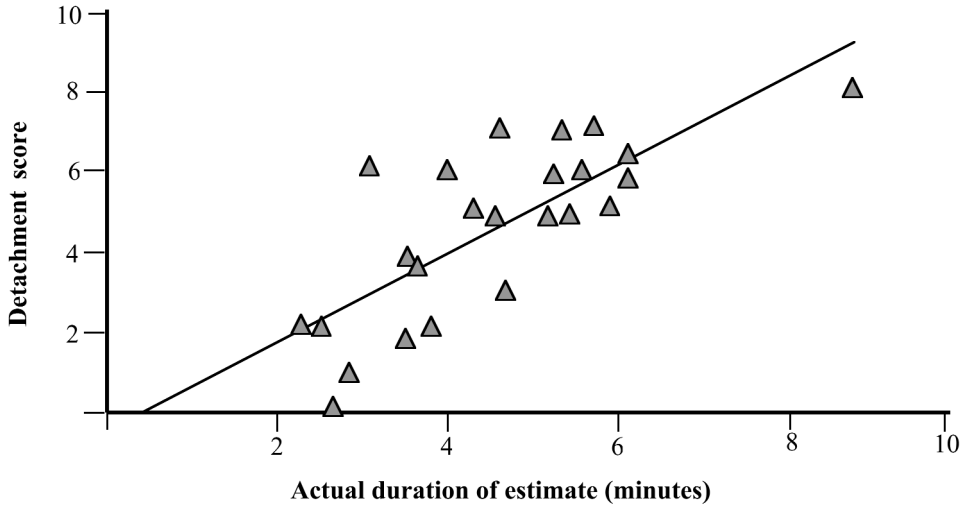

Figure 2. The relationship between detachment and duration of attempted five-minute estimates in experiment 4.

referred to as the essence of hypnosis (although he was not referring to time distortion). This line of reasoning sees hypnosis as being the state that comprises those causes. Thus, hypnosis is a state of detachment, in which a person weakens the role of external reality in determining experiences, and instead generates an internal 'reality', which gives rise to its own set of convincing experiences. This is not a particularly novel definition (see, for example, Barber, 1991), but the novelty lies in the fact that it is no longer simply a *description* of what appears to be happening. This definition encapsulates the factor that appears to be *necessary* in producing a very special hypnotic phenomenon – the one that is not successfully faked by simulators. Moreover, there is a statistically significant correlation between the rated levels of this factor and the accuracy of time judgement. Conventional measures of hypnotic susceptibility do not correlate reliably with the degree of timing error, and no other putative aspect of hypnosis, such as amnesia, has ever been found to produce such a convincing correlation. (See St. Jean et al., 1994 and Naish, 2001 for a discussion of the various hypnotic phenomena that have failed as explanations of timing changes.) Timing effects do not correlate with hypnotic susceptibility so it seems an inescapable conclusion that the factor termed 'detachment' in this paper is not necessarily present to a large extent in those who score high on hypnotic susceptibility scales. The explanation may lie in the idea that there are different forms of hypnosis (Barber, 1999) and that only certain people, such as the fantasy prone, are able to achieve high levels of detachment. Of course, recognition that not all hypnotically susceptible people display a high degree of detachment, calls into question the claim that this is the 'essence' of hypnosis: it may be the essence of one hypnotic style. It should perhaps be acknowledged that the term 'hypnosis', as generally used, is unhelpfully broad; it brings together similar types of overt behaviour, but conceals a variety of cognitive styles. There is clearly a need to explore the relationship between hypnotic style and time distortion. On the basis of the argument offered here, it would be predicted that the

magnitude of the distortion *would* correlate with hypnotic susceptibility, if participants were selected on the basis of their style of hypnosis.

The term 'state' is used in the definition of hypnosis offered above. It has been argued (Naish, 2001) that there are growing bodies both of research data and of researchers to support this label. For example, Barber's recent (1999) theoretical position can be seen as quite 'state like' (Naish, 1999), and various brain-mapping studies implicate rather specific regions of neural activity in the generation of hypnotic experiences (although Wagstaff, 1998, has argued that these are not indicative of a special 'state'). Clearly, the present use of the term will not appeal to those who see a state as an all-or-nothing condition but there are other, non-controversial 'states', such as inebriation, which can be entered along a continuum. However, whereas the neural effects of alcohol are well understood, those of hypnosis remain unclear. Naish (2001) speculated that both the changes in subjective reality and the temporal effects may be mediated by changes in the anterior cingulate cortex. The region is known to be involved in the production of hypnotic hallucinations (Szechtman, Woody, Bowers and Nahmias, 1998) and damage to the area leads patients to experience difficulty in distinguishing real from imagined events (Whitty and Lewin, 1957). A wide variety of brain-mapping studies have shown that, whatever other regions of the brain are involved, hypnosis changes activity in the cingulate (for example, Crawford, Horton, Hirsch, Harrington, Plantec, Vendemia, Shamro, McClain-Furmanski and Downs, 1998; Halligan, Athwal, Oakley and Frackowiak, 2000). The studies cited are concerned with subjective experiences other than temporal perception, but experience and timing can be linked via Gray's (1995) proposal that reality is monitored cyclically. He proposed that there is a continual sequence of sampling the environment and comparing the results with the predictions based upon the previous sample. Details that do not match predictions become the focus of attention and make up the content of consciousness. The neural circuitry proposed by Gray to carry out this process includes the cingulate cortex, and the cycle time was suggested to be of the order of 100 ms. Significantly, Treisman, Cook, Naish and MacCrone (1994) found evidence that the normal 'tick rate' of the internal clock was approximately 80 ms. The similarity between these values invites the speculation that the two cycles may in fact be one and the same. If this were the case, then slowing the environment-sampling cycle would be equivalent to slowing the internal clock, as appears to occur in hypnosis (Naish, 2001). The remaining question to address is why hypnosis should slow the rate at which the environment is sampled. This, it is proposed, is a natural result of detachment from the real environment. When a person succeeds in detaching from reality, is able to become oblivious to normal external information, and replaces real stimulation with self-constructed imagery, then there is no need to keep sampling the environment. If it is sampled, then it will inevitably match the predictions, because it has been constructed so to do. In these circumstances it is suggested that the sample rate, and hence the clock rate, become much slower, with the effects on time perception that are familiar in hypnosis. Even without formal hypnosis, any situation in which a person is able effectively to detach from external reality, replacing it with some degree of internally generated 'reality', will tend to have the same effect upon the experienced passage of time. To explain the 'speeding-up' effects of scale models, Mitchell and Davis (1987) suggested that small models had a higher information density, which in turn made time seem to pass more quickly. Hypnosis, it is proposed, produces low information density, because the hypnotized person does not normally have need to produce a complex, rapidly changing inner world.

Conclusions

The series of experiments reported shows that time distortions, equivalent to the slowing of an internal clock, take place when participants succeed in becoming detached from reality. The impact of detachment, expressed as a substitution of real experiences by self-generated experiences, supports the suggestion (Naish, 2001) that hypnotic timing effects are mediated via a 'consciousness cycle' (Gray, 1995), which, at the neurological level, involves the cingulate gyrus. By generating an inner world of their own, hypnotized people reduce the density of the information available to themselves, and hence the sample rate of their consciousness cycle is reduced. This reduced rate manifests itself in changes to the perception of time. The concept of detachment is important because it correlates with the timing effects observed in these experiments; other aspects of hypnosis have not been shown to produce such a correlation.

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