**Exploring precognition using a repetition priming paradigm.**

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**Abstract**

Controversy has emerged recently over claims that future practice could retroactively facilitate explicit recall in the here and now, with attempts to replicate such findings leading to inconsistent results. Here it is proposed that one possibility for such ambiguous and conflicting findings is that an explicit recall paradigm may be less sensitive to the subtle effects of such phenomena in comparison to an implicit repetition priming paradigm, as this does not rely on conscious processes. In addition, manipulation of a traditional repetition priming paradigm provides an opportunity to address the additional question of whether a single future repetition or multiple future repetitions of a stimulus would be needed to elicit a retroactive facilitation in implicit priming, or more simply a precognitive priming effect. Pilot work led to the development of a functional classification task and this was subsequently used to measure possible precognitive priming effects of 102 native English speakers. The data showed no evidence of precognitive priming when stimuli were repeated only once in the future. However, multiple future repetitions, whilst having no effect on response latencies, did elicit an effect on accuracy such that participants were more accurate when responding to stimuli that would be repeated four times in the future compared to stimuli that were not repeated. The results are discussed and some speculative possibilities are offered. Nevertheless, the lack of robust precognitive priming effects for *both* response times and accuracy means that such a result needs to be interpreted with caution.

**Background**

Some researchers have suggested that it may be possible for a future event to influence some aspect of behaviour in the here and now (see e.g., Bem, 2011; Lobach, 2009; Mossbridge, Tressoldi & Utts, 2012; Radin, 2004). Such unusual effects have been referred to as presentiment (Lobach, 2009; Radin, 2004), unexplained anticipatory effects (Mossbridge, Tressoldi & Utts, 2012) and precognition or retroactive influence (Bem, 2011).

For example, Radin (1997; 2004) used the term presentiment to describe automatic (i.e., no need to imply any conscious awareness) changes in the human nervous system (as measured by electrodermal activity) prior to exposure of an emotional picture. This presentiment effect has been replicated by others (e.g., Spottiswoode & May, 2003) and been found in other physiological measures, for instance, when monitoring functional magnetic resonance imaging (fMRI; Bierman & Scholte, 2002) and heart rate variability (McCraty, Atkinson & Bradley, 2004). More recently Bem (2011) reported on nine experiments designed to test for precognition and retroactive influence. Eight of these showed the predicted pattern of effects – that is, that some future event significantly influenced present behaviour. This included: detection of erotic/negative images; retroactive affective priming and retroactive facilitation of recall.

However, recent attempts to try and replicate some of these effects have been unsuccessful. For instance, Ritchie, Wiseman and French (2012) attempted to replicate the precognitive effects found by Bem (2011) using explicit recall. In three experiments they had participants complete a standard memory recall test which was followed by a ‘practice’ session for half the stimuli. The aim being to see if the *post-test practice* would retroactively influence explicit recall. All three experiments failed to exhibit any evidence of precognition. A similar pattern was reported by Galak, LeBoeuf, Nelson and Simmons (2012) when they attempted to replicate the retroactive effects Bem (2011) reported when using a free recall task. Nevertheless, a more recent meta-analysis reports ‘decisive evidence’ (p.2) in favour of the anomalous anticipation of random future events (Bem, Tressoldi, Rabeyron, & Duggan, 2014).

It is not clear why some seem able to elicit precognitive effects that others cannot find. Statisticians have suggested that this may be due, in part, to the particular analysis used by the researchers. For instance, Wagenmakers, Wetzels, Borsboom and van der Mass (2011) re-analysed Bem’s (2011) original data using a Bayesian analysis and found no evidence in favour of precognition. However, Bem, Utts and Johnson (2011) criticised this approach as utilising an unrealistic prior which in turn led to an underestimation of the experimental effects. A full explanation of the issues regarding the effects of distinct statistical approaches is beyond the scope of this article but further discussion and insights can be found within the literature (e.g., Rouder, Morey & Province, 2013; Storm, Tressoldi & Utts, 2013).

Alternatively, it may be that the original effects reported by Bem are genuine but simply difficult to replicate. This could be due to variation in psi ability and/or the nature of psi itself (see, Kennedy, 2003; Schiltz, Wiseman, Watt & Radin, 2006). A further possibility is that the nature of the task influenced, and/or, interacted with the effect. For example, an explicit recall task is reliant on conscious cognitive processes and these may overshadow or reduce the possible influence of any psi effects. It may be that a task that relies on indirect or *implicit* processes may be more amenable to exhibiting precognitive influences. Such an idea is consistent with the suggestion that anomalous effects may be better understood and explored using indirect or implicit measures (Bargh & Ferguson, 2000).

Hence, the aim of this research was to extend such findings by utilising an implicit repetition priming task, which may be more susceptible/sensitive to anomalous effects given its reliance on non-conscious processing. Also, modifying the traditional repetition priming paradigm to include a post-test phase would make it possible to ascertain whether a single repetition is sufficient to obtain a precognitive priming effect or whether multiple repetitions are required. This could be important, as Bem (2011) had participants scan their ‘practice words’ four times and it is not clear yet what, if any, effect multiple repetition of the stimuli would have on such precognitive effects.

A standard implicit repetition priming paradigm involves two phases, a *study phase* which is followed at various delay intervals by a *test phase*. There is a wealth of literature within cognitive psychology showing that priming an individual with a stimulus (e.g. a word) during the study phase will result in that individual processing the stimulus faster and more accurately when they see it again in the later test phase, despite the fact that they need make no conscious effort to recall the initial exposure (see e.g., Schacter, Wagner & Buckner, 2000). Hence, this project utilised this well established paradigm and reversed the direction of focus to explore potential retroactive influences. That is, whether it is possible that repeating a stimulus in the test phase will retroactively influence performance in the previous study phase. In addition, by incorporating a post test phase that presented a subset of items from the test phase multiple times, it would be possible to test whether additional repetitions of a stimulus in the post-test phase would retroactively influence performance in the previous test phase. In both cases the prediction was that participants would respond in less time *and* more accurately to material in the study and test phases that they ‘*will*’ see again in the test and post-test phases respectively, compared to material that is not repeated.

**Pilot Study 1: Identifying a suitable priming task**

An initial pilot study was developed to identify a possible priming paradigm. The aim was to create a priming paradigm that would ensure that participant’s performance had not reached ceiling during the test phase and as such allow for the possibility of a precognitive priming effect when comparing response times and errors in the test phase for those items that would be repeated in the post-test phase to those that would not. A semantic classification task was used (i.e., classifying words as referring to either living vs. non-living objects) as this type of implicit task typically involves using conceptual processing and requires more time than a simple word naming task and hence was thought less likely to exhibit ceiling effects (see, Roediger & McDermott, 1993).

**Method**

***Participants***

Fourteen participants (3 males and 11 females) aged 18-27 (mean 19.2y; SD 2.35y) completed this initial pilot. All participants were undergraduate students from CCCU with normal/corrected to normal vision and native English speakers.

***Materials***

Six main word lists, each consisting of 24 words with 12 relating to living animals and 12 words relating to non-living items, were created. All words were taken from the SUBTLEXUS database (<http://expsy.ugent.be/subtlexus>) and the lists were matched for mean word frequency using the SUBTL frequency norms (see, Brysbaert & New, 2009). Following Bem (2011), a two-item scale was also used to assess stimulus seeking composed of the two statements: “I am easily bored” and “I often enjoy seeing films I’ve seen before” (reverse scored). Responses were recorded on 5-point scales that ranged from Very Untrue to Very True and averaged into a single score ranging from 1 to 5. An image from the Hubble space telescope (image reference M17: Omega Nebula) was also used alongside some relaxing new age music (The mists of Avalon.wav). All experiments used a Super RiteMaster computer tower installed with Windows 7 enterprise and an Intel(R) Core(TM)2 Duo CPU processor with SuperLab 4.5 (Cedrus Corporation) presentation software and an RB-530 response pad.

***Design***

The eight stages in the experiment are illustrated in Figure 1. The participant first answered the two stimulus seeking questions from Bem (2011), followed immediately followed by a 3-minute relaxation period where the participant listened to soft music and was shown an image from the Hubble space telescope. Ten practice trials were then completed, followed by the *study phase*, which in turn was followed by a *blink break,* the *test phase*, a second *blink break* and finally the *post-test phase.*

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Figure 1 about here

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Presentation of the six word lists in the conditions of the study, test and post-test phases was completely counterbalanced, ensuring that each word list occurred equally often in the repeated and non-repeated/new conditions, creating 12 possible variations, see Figure 2 below. This meant that within each phase (Study, Test and Post-test) participants were exposed to a total of 96 words.

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Figure 2 about here

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***Procedure***

Consistent with the work of Bem all participants were made aware that the experiment tested for ESP, although precisely how it tested for this was not explained until they had completed the experiment. Each participant was tested individually in a quiet room. They began by completing a consent form followed by answering the stimulus seeking questions. The experimenter then explained the task to them (semantic classification) and allowed them the opportunity to ask any questions. Following this, and in line with Bem’s work, and others, computers were used to standardise the delivery of the stimuli. So, once the participants were clear what it is they had to do the experimenter initiated the computer program and left them alone in the room.

The computer began by showing an image taken from the Hubble space telescope and simultaneously playing some new-age type music for 3 minutes. The aim of this was to provide participants with a brief relaxation period prior to the experiment allowing them to become familiar with the environment (see, Bem, 2011). At the end of this period the computer displayed an instruction screen informing the participant that they would subsequently be presented with a series of words and that their task was to classify the words as relating to living or non-living objects. The computer then presented ten practice trials (5 living words and 5 non-living) not included in the other lists to ensure that participants were clear about what was expected of them and to help them become familiar with the expectations of the task. Participants responded by pressing one of two buttons on an RB-530 response pad (Cedrus Corporation) with the index fingers of both hands. The left-right orientation was counterbalanced across participants to control for possible handedness effects. At the end of this stage the computer showed a query screen which asked if the participant had any queries/questions and if so to call in the experimenter, and if not to simply press any key to continue. Once a key was pressed the computer moved on to the study phase and randomly presented items from four word lists of 24 words (i.e., 96 words) and participants responded to each item, identifying it as either ‘living’ or ‘non-living’. There was a short blink-break before the test phase began. During this phase, the computer again randomly presented stimuli from four word lists each containing 24 words, with two of the word lists repeated from the study phase and two new word lists. This was again followed by a short blink-break and then the post-test phase, in which the computer randomly presented one of the word lists of 24 words that had been used in both the study and test phase four times. Hence, in each phase; study, test and post-test, participants classified 96 words.

**Ethics**

Full University Faculty ethics approval was obtained for all the studies. This involved an initial risk assessment for each study, and included obtaining written consent from all participants and providing information assuring them that participation in the study was entirely voluntary and that they were free to withdraw at any time, and have their data destroyed, and that any data collected would be anonymised to protect their identity.

**Results**

The aims of this pilot were twofold. First, to test whether the paradigm was sensitive to standard priming effects and second to ensure that a response ceiling had not been reached in the test phase. Standard priming was measured as the difference in response times and error scores between the two repeated word lists and the two new word lists introduced in the test phase. Possible ceiling effects were examined by comparing response times for the list repeated in the post-test phase with the same list presented in the previous test phase. It should be noted that throughout this study, and the subsequent ones, two-tailed t tests were used as these would allow for the possibility of results in the opposite direction (see Ritchie et al., 2012).

*Standard Priming Effect*

A standard priming effect was found with participants responding in less time to primed items seen in the study phase compared to new unprimed items (576.57 ms and 605.81 ms respectively) *t*(13) = 5.175, *p* = 0.001, *d* = 0.35. Participants were also more accurate when responding to repeated items compared to new items (2.67% and 5.50% errors respectively) *t*(13) = 3.277, *p* = 0.01, *d* = 0.87.

*Possible Ceiling Effects*

However, mean response times for the subset of items repeated in the post-test phase did not differ from the same items in test phase, (564 ms and 576 ms respectively) *t*(13) = 0.99, *p* = 0.34. Analysis of error scores indicated that participants made more errors responding to the same items during the post-test phase compared to the same items during the test phase (4.68% and 2.67% errors respectively) *t*(13)0 = 2.240, *p* = 0.05, *d* = 0.69.

**Conclusion**

The semantic classification pilot study showed clear evidence of a standard priming effect however, participants’ response times (RT) did not significantly improve from the test to the post-test phase suggesting that they had reached a possible ceiling in terms of response times after a single repetition. Interestingly, their error scores increased from the test to the post-test phase. Nevertheless, given that participants had reached a ceiling effect in the test phase it would be unlikely that further repetitions of the stimuli in the post-test phase would be able to elicit any precognitive priming effects in the prior test phase. Hence, a different priming task was sought.

**Pilot Study 2: A different priming task**

To try and address the ceiling effects evident in the test phase response times of the semantic classification task a functional classification task was developed, based on work showing that this required more conceptual processing, which in turn would require more time and be less susceptible to ceiling effects (see, Thompson-Schill & Gabrieli, 1999). This task involved the presentation of word pairs and required participants to identify whether the two words presented referred to objects that had the same/or similar function (e.g., apron – overall) or not (e.g., strawberry – colander).

**Method**

***Participants***

Twelve participants (11 female and 1 male) aged 18y to 30y with a mean age of 19.3y completed the experiment for course credits.

***Materials***

As before six lists were created but this time each list contained 16 word pairs, 8 functionally similar and 8 functionally dissimilar. The mean co-occurrence ratings of each of the six lists were matched (see, Rhode, Gonnerman & Plaut, 2008) and as before each list was rotated through the various phases of the experiment to ensure that each word pair appeared in each condition an equal number of times.

***Design & Procedure***

The general design and procedure of this pilot study remained the same as the previous classification task. The only difference here was that when presented with a word-pair the participant’s task was to identify whether the two words referred to functionally similar items (e.g., Desk – Table) or not (e.g., Lantern – Gun). Again all responses were collected via an RB-530 response pad with left-right order counterbalanced across participants.

**Results**

*Standard Priming Effect*

A standard priming effect was found with participants responding in less time to repeated items seen previously in the study phase compared to new items (877.67 ms and 1023.55 ms respectively) *t*(11) = 5.976, *p* = 0.001, *d* = 0.92. However, there was no difference in error scores between repeated and new items (5.98% and 9.11% respectively) *t*(11) = 1.732, *p* = 0.11.

*Possible Ceiling Effects*

Mean response times for the subset of items repeated in the post-test phase were also lower (i.e., faster) compared to the same items in the test phase, (667.71 ms and 877.43 ms respectively) *t*(11) = 6.632, *p* = 0.001, *d* = 1.93. Once again, however there was no difference in error scores between items in the test phase that were repeated in the post-test phase (4.16% and 3.91% respectively) *t*(11) = 0.181, *p* = 0.86.

**Conclusion**

This pilot study clearly showed that such a paradigm would be sensitive to standard priming effects *and* that a single repetition was not sufficient to elicit ceiling effects in response times. Hence, this paradigm was adopted for the main study.

**MAIN STUDY**

***Participants***

Given the effect sizes reported by Bem (2011) an opportunity sampling approach was utilised and the main functional classification task was conducted on a separate population of 102[[1]](#footnote-1) participants (26 Male, 76 Female), aged 18y to 39y (Mean age of 19.9y). All participants were native English speakers had normal or corrected to normal vision and were either paid a fee of £5 or received course credits for taking part.

***Method***

The design remained the same as in previous pilot task.

**Results**

Data from the study phase and the test phase was analysed separately. Response time data and error data were also analysed separately. Consistent with Bem’s (2011) approach repeated measures t tests were used to compare means in order to keep the analysis simple and transparent. However, unlike Bem two-tailed tests were used as these would allow for the possibility of results in the opposite direction (see Ritchie et al., 2012).

In the study phase precognitive priming was measured as the difference in response time and accuracy between the word lists that were subsequently repeated in the test phase and the lists that were not repeated (see Figure 3a).

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Figures 3a-3c about here

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The test phase involved conducting multiple comparisons which raises the risk of a Type 1 error and a useful way of dealing with this possibility is to include an alpha correction such as the Bonferroni procedure (Howell, 1996). However, a simple blanket approach to using the Bonferroni correction for multiple comparisons can produce very conservative criterion levels and increase the risk of a Type 2 error (see, Field, 2009). A traditional approach to dealing with this issue is to utilise the Bonferroni correction in a staged or stepwise manner where the alpha correction is incorporated at each additional stage of the procedure (de Cani, 1984; Rosenthal & Rubin, 1984). With such an approach it has been suggested that the order of the comparisons could influence the results and as such the order should reflect the importance to the theory of the confirming presence or absence of a possible effect (see, de Cani, 1984). Hence, the two comparisons made in the test phase are made in the order of testing for multiple precognitive priming followed by standard priming. Where multiple precognitive priming was measured as the difference in response time and accuracy between the list that was repeated four times in the post-test phase and the list that was not repeated (Figure 3b). Standard priming effects were examined in the test phase by comparing the difference in response time and accuracy between the repeated word lists (i.e., Primes in the test phase) and non-repeated lists (Figure 3c). Correlations were also conducted between participants’ stimulus seeking scores and any indication of precognitive priming.

*Precognitive Priming*

Response Times

In the study phase, there was no difference in RTs between items that were later repeated and those that were not (1053 ms and 1056 ms respectively) *t*(101) = 0.385, *p* = 0.701 (see Table 1).

Error Scores

There was no difference in participants’ errors when classifying items that were subsequently repeated compared to those that were not (9.28% and 8.91% respectively) *t*(101) = 0.491, *p* = 0.624.

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Table 1 about here

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*Multiple Precognitive Priming*

Response Times

In the test phase, there was no difference in RTs between items that were later repeated and those that were not (901.2 ms and 906.3 ms respectively) *t*(101) = 0.641, *p* = 0.523.

Error Scores

Participants made fewer errors when classifying items that were subsequently repeated compared to those that were not (4.47% and 6.25% respectively) *t*(101) = 2.450, *p* = 0.016, *d* = 0.26 (see Table 2). Error scores for both the repeated and non-repeated, as well as the difference between the two, were compared with stimulus seeking scores to assess whether there was any correlation. No significant correlations emerged between stimulus seeking scores and error scores for the repeated items (*r*(102) = 0.062, *p* = 0.536), non-repeated items (*r*(102) = -0.058, *p* = 0.564), or the differences between the two (*r*(102) = -0.109, *p* = 0.276).

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Table 2 about here

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*Standard Priming*

Response Times

In the test phase, participants were faster to respond to repeated items compared to new items (903.7 ms and 1047.5 ms respectively) *t*(101) = 18.676, *p* < 0.001, *d* = 0.82 (see Table 3).

Error Scores

Participants made fewer errors when classifying items that were repeated compared to those that were not (5.36% and 9.37% respectively) *t*(101) = 6.460, *p* < 0.001, *d* = 0.68.

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Table 3 about here

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**DISCUSSION**

The aims of this study were to ascertain whether single or multiple repetitions of a stimulus at some future stage would influence implicit memory, as measured by repetition priming, in the here and now. Two pilot studies were developed to ensure that the final paradigm would be sufficiently sensitive to exhibit traditional priming in the test phase and that such performance did not exhibit a ceiling effect in the test phase. Thereby providing for the possibility of future stimulus repetitions to have a reverse time effect. However, when looking at the response times of the main study there was no evidence of any precognitive priming effect in either the study or the test phase, although a standard priming effect in the test phase is robustly evident. Nevertheless, when looking at accuracy performance in the test phase an anomalous pattern does emerge. In the test phase participants were more accurate when classifying items that *would be* repeated in the subsequent post-test phase compared to those that were not.

As such, data from the study phase would suggest that a single repetition of material in the future is insufficient to elicit evidence of a precognitive priming effect. Such a finding is consistent with previous attempts that have failed to find evidence of retroactive facilitation of recall following multiple practice attempts (Galak et al., 2012; Ritchie et al., 2012) and extends their work to show that a single future repetition is also insufficient. The failure of the main study to show any evidence of precognitive priming for response times when material is repeated multiple times in the future is also consistent with this view and may fit with the interpretation that such effects are merely the result of statistical and/or methodological artifacts (e.g., Wagenmakers et al., 2011). However, an anomalous pattern emerged for the error data in the test phase and whilst the author would wish to abide by the principle of Occam’s razor he would not wish to be accused of using Occam’s broom.

*Occam’s Razor vs. Occam’s Broom*

Most people should be familiar with the concept of Occam’s razor or the principle of parsimony. However, Occam's broom is a somewhat more recent conceit, attributable to Sydney Brenner, and embodies the principle whereby inconvenient facts are swept under the carpet in the interests of a clear interpretation of a messy reality (see Robertson, 2009). Hence, some account should be offered for the anomalous pattern of error data seen in the test phase.

The anomalous effect in error scores in the test phase is suggestive of a precognitive priming effect. That such an effect was not evident in the initial study phase would suggest that multiple repetitions are required to elicit such an effect, a pattern that would be consistent with previous work (see, Bem, 2003). Of course it remains an open question as to the nature of the relationship between the number of repetitions and the strength of the effect. Nevertheless, it is not clear why no precognitive priming effects were evident in the response time data and this could be taken to suggest that response times and accuracy may rely on distinct aspects of processing and as such may be differentially influenced by possible precognitive effects. For instance, early views of response times as a dependent variable of memory performance have argued that response time data is a more sensitive measure of behavioural change than errors (see e.g., Wearing & Montague, 1970). Furthermore, analysis of the standard priming effects from the main study here shows robust priming of both response times *and* error scores, and interestingly the effect size for response times is greater than that for errors. This would be consistent with the notion that response times *are* a more sensitive indicator of behavioural change compared to errors.

However, others have suggested that accuracy may at times be more sensitive than latency and that accuracy and speed of responses may in fact tap distinct aspects of memory (MacLeod & Nelson, 1984). This in part is influenced by the nature of memory itself, that is, whether memory is unidimensional or multidimensional. If an intervention elicits an empirical outcome on error probability that is distinct and/or different from that measured by latency it is tempting to suggest that this may be due to the multidimensional nature of memory. Indeed, MacLeod and Nelson (1984) have argued that different ‘processes can affect these two dependent variables in qualitatively different ways’ (p.230). Thus, accuracy and latency may not represent indices of a single underlying dimension of memory. If this is the case then the aspect of memory represented by accuracy may be more susceptible to precognitive influences as compared to that aspect responsible for the speed of a response. However, it should be noted that this is a speculative possibility and that more work and further replications of this effect are needed before such a tentative possibility can be accepted.

A further speculative possibility is that the processes involved in precognition may be distinct from those that support implicit memory. Whilst there is no single accepted view of the basis of implicit memory researchers have suggested that it may be supported by the automatic activation of pre-existing representations (Graf & Mandler, 1984) and/or the overlap in processing operations carried out at study and at test (Morris, Bransford & Franks, 1977; Roediger, 1990). Hence, precognitive priming *could* be based on the similarity in processing operations between the phases of experiment reported here, simply operating in a reversed temporal direction. However, given that the basis of precognition is as yet unknown such proposals are speculative and need to be interpreted with caution. As such, a possible reason why no clear precognitive priming effects were evident in this study is that the nature of precognition is distinct from and reliant upon different processes to that of implicit memory.

Whilst robust precognitive priming effects were not obtained in this study such a result should not be taken to indicate that such an effect is either not possible or simply unobtainable using this paradigm. The lack of a robust precognitive priming effect may have been influenced by a range of other mediating factors such as the specific stimuli used, the gender of the participants as well as their personal beliefs. For instance, the stimuli used here were simple everyday words relating to specific objects (e.g., apron – overall) and research has suggested that precognitive effects may be proportional to the physiological impact of the stimuli used (Lobach, 2009). The argument here is that stimuli that elicit stronger feelings of pleasure and/or discomfort may be better suited to producing precognitive effects. In addition, others have shown that females may be more sensitive to precognitive effects compared to males (see, Radin & Lobach, 2007). Furthermore, it has been shown that individuals who believe in psi phenomenon may exhibit greater psi performance compared to their more sceptical counterparts (see e.g., Walsh & Moddel, 2007). Hence, future research could utilise this implicit priming paradigm and incorporate these points to further explore the possibility of precognitive priming.

Of course, a potentially more parsimonious explanation is that the anomaly in the error scores for the test phase may simply represent a Type I error. Whilst a Bonferroni correction was utilised when additional comparisons were made in a stepwise fashion it is important, given the potential interpretation placed on the anomalous error scores, to realise that such a correction merely reduces the probability of Type I errors, it does not preclude them. Furthermore, the fact that there were no differences in error scores in the second pilot study lends weight to the notion that this could simply be a spurious effect.

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Completion of stimulus seeking items

Blink break

**POST TEST PHASE**

**TEST PHASE**

Blink break

**STUDY PHASE**

3-mins of relaxing music with image

10 practice trials

Figure 1**.** The eight stages of the experiment.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Study Phase** | | | | **Test Phase** | | | | **Post Test Phase** |
|  | **Repeated** | | **Not Repeated** | | **Repeated** | | **New** | | **Repeated x4** |
| Word lists | 1 | 2 | 3 | 4 | 1 | 2 | 5 | 6 | 1 |
| Word lists | 1 | 2 | 3 | 4 | 1 | 2 | 5 | 6 | 2 |
| Word lists | 1 | 2 | 5 | 6 | 1 | 2 | 3 | 4 | 1 |
| Word lists | 1 | 2 | 5 | 6 | 1 | 2 | 3 | 4 | 2 |
| Word lists | 3 | 4 | 1 | 2 | 3 | 4 | 5 | 6 | 3 |
| Word lists | 3 | 4 | 1 | 2 | 3 | 4 | 5 | 6 | 4 |
| Word lists | 3 | 4 | 5 | 6 | 3 | 4 | 1 | 2 | 3 |
| Word lists | 3 | 4 | 5 | 6 | 3 | 4 | 1 | 2 | 4 |
| Word lists | 5 | 6 | 1 | 2 | 5 | 6 | 3 | 4 | 5 |
| Word lists | 5 | 6 | 1 | 2 | 5 | 6 | 3 | 4 | 6 |
| Word lists | 5 | 6 | 3 | 4 | 5 | 6 | 1 | 2 | 5 |
| Word lists | 5 | 6 | 3 | 4 | 5 | 6 | 1 | 2 | 6 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Total words  per condition | 48 | 48 | 48 | 48 | 96 |

Figure 2**.** Rotation of the six word lists (each containing 24 words) through conditions, with total number of words presented in each condition.

|  |  |  |
| --- | --- | --- |
| **Study Phase** | **Test Phase** | **Post Test Phase** |
| Word list 1 | Same word list 1 | Same word list 1  x 4 |
| Word list 2 | Same word list 2 |
| Word list 3 | New word list 5 |
| Word list 4 | New word list 6 |

Figure 3a. Precognitive priming;

|  |  |  |
| --- | --- | --- |
| **Study Phase** | **Test Phase** | **Post Test Phase** |
| Word list 1 | Same word list 1 | Same word list 1  x 4 |
| Word list 2 | Same word list 2 |
| Word list 3 | New word list 5 |
| Word list 4 | New word list 6 |

Figure 3b. Multiple precognitive priming.

|  |  |  |
| --- | --- | --- |
| **Study Phase** | **Test Phase** | **Post Test Phase** |
| Word list 1 | Same word list 1 | Same word list 1  x 4 |
| Word list 2 | Same word list 2 |
| Word list 3 | New word list 5 |
| Word list 4 | New word list 6 |

Figure 3c. Standard priming.

|  |  |  |
| --- | --- | --- |
| **Study Phase** | | |
|  | **Repeated** | **Not Repeated** |
| **Mean RT (SD)** | 1053.44 (202.4)ms | 1056.16 (201.8)ms |
| **Mean % Error (SD)** | 9.28% (6.9%) | 8.91% (6.6%) |

**Table 1.** Mean response times (in milliseconds) and percentage errors with standard deviations in parenthesis for repeated and not-repeated conditions in the Study phase.

|  |  |  |
| --- | --- | --- |
| **Test Phase** | | |
|  | **Repeated** | **Not Repeated** |
| **Mean RT (SD)** | 901.22 (157.5) | 906.33 (165.7) |
| **Mean % Error (SD)** | 4.47% (5.4%) | 6.25% (7.9%) |

**Table 2.** Mean response times (in milliseconds) and percentage errors with standard deviations in parenthesis for test phase items that were repeated again in the later post-test phase and not repeated in the post-test phase.

|  |  |  |
| --- | --- | --- |
| **Test Phase** | | |
|  | **Repeated** | **New** |
| **Mean RT (SD)** | 903.77 (156.6)ms | 1047.53 (193.9)ms |
| **Mean % Error (SD)** | 5.36% (5.7%) | 9.37% (5.9%) |

**Table 3.** Mean response times (in milliseconds) and percentage errors with standard deviations in parenthesis for items repeated from the previous study phase (i.e., primed) and new items not seen in the previous study phase.

1. Based on the small effect size of the retroactive influence reported by Bem (2011) *d* = 0.29 and adopting the standard alpha criterion of 0.05 (two-tailed), coupled with a test that has the statistical power of 0.8, the required sample size can be calculated using Howell’s (1996) sample calculation, where power of 0.8 as a function of significance at 0.05 (two-tailed) translates into a δ score of 2.80 (Appendix Power Tables from Howell, 1996). Hence, N = (2.80/0.29) 2 gives: 9.652 which equals 93. Thus, a minimum of 93 participants was required. [↑](#footnote-ref-1)