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Subliminal Understanding of Active Versus Passive Sentences

Anna-Marie Armstrong and Zoltan Dienes
University of Sussex

Three experiments were run in an attempt to demonstrate the unconscious processing of active-versus-passive sentences. Using subjective measures to assess individual thresholds of subliminal perception, participants were presented with a prime sentence that denoted whether 1 of 2 characters was active or passive within the sentence (e.g., "A is injecting B," "A is injected by B"). When subsequently required to choose between 2 pictorial representations (i.e., character A as active, character B as active), participants were able, overall, to identify the correct images for both active and passive conditions beyond chance expectations (when averaged over all experiments). As expected, participants also took longer to respond to passive than active sentences. In sum, the present research demonstrates that people are able to process the meaning of word combinations that they are not consciously aware of seeing.

Keywords: subliminal priming, subjective thresholds, contrast masking, unconscious cognition, multiple word priming

In a typical subliminal priming experiment, a briefly presented prime is prevented from entering conscious perception through the use of either a forward (before the presentation of the prime) or backward (following the presentation of the prime) mask (Perfetti & Bell, 1991). This mask is typically in the form of either a pattern mask (i.e., a distribution of target fragments, random letters, or symbols) or a noise mask (i.e., a mask composed of a set of random dots or squares) (Delord, 1998). Short presentation durations in combination with the mask then render the prime unconscious by interfering with conscious visual processing and analysis of the prime. When subsequently presented with a test stimulus, successful subliminal priming is assumed to have occurred if the prime has in some way influenced the processing of the test stimulus (Johnston & Dark, 1986). Although studies demonstrating simple analyses of subliminal primes are commonly accepted within psychological research (Abrams & Greenwald, 2000), there nevertheless exists a considerable debate regarding whether or not the semantic processing of subliminal stimuli is possible (Naccache & Dehaene, 2001).

An enduring question within the literature is just how intelligent unconscious cognition can be (e.g., Greenwald, 1992; Loftus & Klinger, 1992; Marcel, 1980; Peirce & Jastrow, 1884; Sklar et al., 2012). Many studies indicate that the presentation of a subliminally presented word subsequently facilitates lexical and semantic access (e.g., Abad, Noguera, & Ortells, 2003; Carr & Dagenbach, 1990; Dell"Acqua & Grainger, 1999; Draine & Greenwald, 1998; Forster & Davis, 1984; Fowler, Wolford, Slade, & Tassinary, 1981; Gaillard et al., 2006; Marcel, 1983a). However, controversy regarding the extent of unconscious priming remains (Abrams & Greenwald, 2000; Damian, 2001; Hutchison, Neely, Neill, & Walker, 2004; Kouider & Dupoux, 2004); with Greenwald (1992) arguing that the effects of subliminal perception are far less sophisticated than is often reported. For example, rather than semantic access to subliminal primes, many researchers have instead attributed the effects of subliminal perception to the retrieval of stimulus-response (S-R) links (i.e., conscious rehearsal of prime-

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Anna-Marie Armstrong, School of Psychology, University of Sussex, Brighton, United Kingdom; Zoltan Dienes, School of Psychology and Sackler Centre for Consciousness Science, University of Sussex.

Correspondence concerning this article should be addressed to Anna-Marie Armstrong, School of Psychology, Pevensey Building, Room 2A13, University of Sussex, Brighton BN1 9QH, United Kingdom. E-mail: aa293@sussex.ac.uk

target combinations lead to the creation of an episodic memory trace between stimulus and response that is reactivated upon subliminal presentation, leading to the illusion of priming effects, e.g., Damian, 2001; Kunde, Kiesel, & Hoffmann, 2003; Schlaghecken & Eimer, 2004), sublexical priming (i.e., processing of subliminal words or sentences is limited to the processing of subword elements, e.g., Abrams & Greenwald, 2000), or partial conscious awareness (Kouider & Dupoux, 2004).

An explanation that has been offered in an attempt to account for the failure of many studies to demonstrate successful subliminal semantic priming of single and even multiple words focuses on the use of objective thresholds when measuring subliminality. When assessing unconscious cognition, objective methods presume that any trial accuracy above chance level performance indicates conscious knowledge (Seth et al., 2010). For example, in the Greenwald and Liu (1985) study investigating multiple word priming the stimulus onset asynchrony (SOA—the time interval between the onset of one stimulus to the onset of the next) for subliminal trials was determined by the point at which performance accuracy in determining whether the words LEFT or RIGHT appeared at the left or right hand side of the screen fell *below* chance level performance. As a consequence, it is not then surprising that participants were unable to unconsciously analyze the semantic function of a two word prime. The use of objective thresholds in assessing subliminal perception do not just test for unconscious cognition, but degraded unconscious cognition (Dienes, 2007; Lau & Passingham, 2006).

It was Cheesman and Merikle (1984, 1986) that first distinguished between objective and subjective thresholds, with the subjective threshold referring to the point at which participants *believed* they were performing at chance, and the objective threshold referring to the point at which they *were* performing at chance. Their results indicate that the unconscious analysis of subliminal primes occurs below the subjective threshold, but that unconscious cognition below the objective threshold is limited. (cf. e.g., Masters, Maxwell, & Eves, 2009) The subjective threshold, whose function is to measure the point at which participants are not aware of seeing, allows a fuller investigation of the limits of the unconscious when compared with the objective threshold, which degrades not only conscious seeing, but also seeing itself (cf. Dienes & Seth, 2010a, 2010b).

Sklar et al. (2012) similarly argued that back masking with objective thresholds unnecessarily confounds processing time with whether processing is subliminal versus supraliminal. That is, as the subliminal condition has typically involved very rapid presentation of the stimulus, it is not then surprising that the level of processing can be low compared with conscious processing over extended times. Thus, Sklar et al. used continuous flash suppression (CFS; the presentation of a rapidly changing stimulus to one eye to prevent the conscious perception of a further static stimulus presented to the other eye, Tsuchiya & Koch, 2005), which allowed presentation of stimuli over hundreds of millis (rather than e.g., 16–32 ms for back masking at objective threshold). They argued that using CFS, participants could be shown to semantically process word and number combinations subliminally. Specifically, they found that coherent sentences (e.g., “I made coffee,” “I ironed clothes”) broke through suppression slower than incoherent sentences (e.g., “I ironed coffee”). These results are intriguing, though somewhat different individual words were presented in the congruent and incongruent conditions (e.g., “made” vs. “ironed”). In another series of experiments, three-term subtractions (e.g., “9 – 4 – 5”) primed processing of their solutions (e.g., time to pronounce “0”). These results raise the question of what sort of novel combinations can be processed subliminally, and also under which conditions subliminal processing can fully express itself. Thus, we will explore processing of word combinations using back masking or contrast degraded stimuli, and to promote rich unconscious processing, we will use subjective rather than objective thresholds.

Whereas mental arithmetic (cf. Sklar et al., 2012) appears to involve executive resources even for single digit problems (DeStefano & LeFevre, 2004), the resources needed for processing syntax is less clear. The processing of the syntax of single simple clauses appears automatic and unconscious (see, e.g., Li, Guo, Zhu, Yang, & Dienes, 2013; Rebuschat & Williams, 2009; Williams, 2009, for the implicit learning of syntactic structures), and it has been argued such syntactic processing does not take up executive resources (Caplan & Waters, 1999, though see accompanying commentary). If a three term subtraction can be performed subliminally, parsing simple syntax for a few words should be possible. Armstrong and Dienes (2013) used back masking at subjective thresholds to investigate subliminal processing of word combinations involving negation. Participants were subliminally primed with either for example, "pick dog" or "not dog" then asked to select from two words, for example, "dog" or "cat." The pick instruction was associated with picking the noun at above baseline levels, and the "not" instruction with picking the noun at below baseline levels. Thus, participants must have subliminally processed word combinations.

We will use a similar methodology but explore the processing of active versus passive syntax. The present research consists of presenting participants with textual primes that depict one of two characters (either character A who was always female, or character B who was always male) as either active or passive within the sentence (e.g., "A is attacking B," "A is attacked by B," "B is attacking A" or "B is attacked by A"). When subsequently presented with two schematic images, one in which character A is active while character B is passive, and the other in which character A is passive while character B is active, the participant was required to choose the picture that best represents the prime.

Conscious comprehension during reading involves a set of processes that range from the recognition of certain patterns in the printed material, such as letters and words, to the construction of an abstract representation of the text (Carreiras, Garnham, Oakhill, & Cain, 1996). This representation of the situation described in the text is known as a mental model. If it is possible to correctly identify the schematic image representing the sentence prime, beyond chance expectations, this may suggest that the participant was able to draw sufficient semantic information from the subliminal prime to allow for the creation of a mental model. This mental model would then enable the individual to map this model onto the most appropriate schematic representation available. To our knowledge, whether or not unconscious cognition is sophisticated enough to differentiate between activity and passivity remains an unexplored avenue of research. Therefore, using individual subjective thresholds for novel stimuli, if identification of the correct schematic image is above chance expectations then this would indicate that unconscious cognition is capable of carrying out more complex analyses than previously assumed (e.g., Abrams & Greenwald, 2000; Greenwald, 1992), and consistent with the arguments by Sklar et al. (2012) and Armstrong and Dienes (2013) that word combinations can be subliminally processed.

Experiment 1

Although practiced stimuli have often been shown to produce superior priming effects when compared with unpractised novel stimuli (Draine & Greenwald, 1998), criticisms have arisen due to the likelihood that successful subliminal priming merely relies on the retrieval of S-R links established during conscious rehearsal (Forster & Davis, 1984). Therefore, in Experiment 1, participants first completed a set of conscious trials to accustom themselves to the task required, which differed from the content of subliminal trials. However, to achieve maximum likelihood of successful subliminal priming while controlling for S-R links, participants consciously viewed the list of verbs (in their simple present form, e.g., injects, washes etc.) to be used in subliminal trials in an attempt to activate schematic representations but in isolation from a given motoric response, thereby preventing the formation of S-R links.

We expected that for the conscious trials, participants would identify the correct schematic image on close to 100% of the trials for both active and passive conditions. For the subliminal trials, using subjective thresholds of conscious awareness, we hypothesized that participants would identify the correct schematic image for both active and passive conditions beyond chance expectations (that is, beyond 50%). In addition to trial accuracy, response times (RTs) would be measured with the expectation that identification of the correct image in the active condition would be faster than in the passive condition.

Method

Design and participants. In a repeated measures design with the number of correct schematic image identifications being the dependant variable, 31 undergraduate psychology students from the University of Sussex took part in this study in exchange for course credits. Twenty-three of the participants were female and eight male, with ages ranging from 18 to 35 years (M = 22.93, SD = 5.6).

Apparatus and materials. The experiment was created using E-Prime version 2.0 and presented on a Dell laptop with a 60Hz screen refresh rate, limiting minimum stimulus presentation to 16 ms, with 16 ms increments. Each textual screen display was centrally presented in lower-case, black, bold Courier New font, and point size 18 on a white background. Conscious trials were created from a set of four verbs (e.g., *pokes, burns*), and subliminal trials were created from a set of 12 verbs (e.g., *injects, films*). All verbs in conscious and subliminal trials were chosen on their ability to be suitably represented in a pictorial format. Examples of the type of schematic image used can be seen in Figures 1 and 2.

The arrangement of sentence-image trials were counterbalanced to ensure participants viewed each of the eight prime-image permutations for each verb, e.g., (a) "A is injecting B", first image A injecting B, and second image B injecting A; (b) "A is injecting B" first B injecting A, second A injecting B; (c) "A is injected by B" first A injecting B, second B injecting A; (d) "A is injected by B" first B injecting A, second A injecting B; (e) "B is injecting A" first A injecting B, second B injecting A; (f) "B is injecting A" first B injecting A, second A injecting B; (g) "B is injected by A" first A injecting B, second B injecting A; (h) "B is injected by A" first B injecting A, second B injecting A, creating a total of 32 conscious trials and 96 subliminal trials. Therefore, each verb created four trials in which A was the active protagonist and B was passive, and an additional four trials in which B was the active protagonist and A passive.

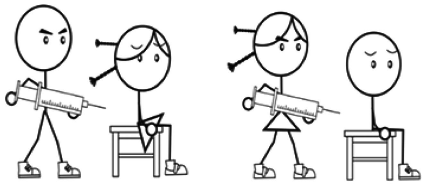

Figure 1. An image depicting the verb "injects". In the first image, B is active; in the second image, A is active.

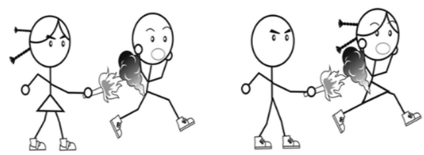

Figure 2. An image depicting the verb "burns". In the first image, A is active; in the second image, B is active.

Procedure. Participants were individually tested by the researchers in a small quiet room in which the participant sat before a laptop such that their eyes were approximately 60 cm from the monitor screen. Once it had been explained to the participant that they would be taking part in an unconscious processing study, they were left alone to complete the experiment, thereby minimizing the potential role of experimenter demand characteristics. All participants had normal or corrected to normal vision, and English was the first language for all participants. Each of the conscious and subliminal trials consisted of four separate components: a fixation cross presented at the center of the screen for 350 ms, the prime sentence (e.g., "A is injecting B" or "A is injected by B"), a backward mask in the form of a series of ampersands (i.e., &&&&&&&&) designed to exceed the length of the sentences (and were the same length for active and passive trials) presented for 150 ms, and the final component consisting of the two image choice depicting both A and B as active protagonists. Participants were required to indicate the number with a key press (either No. 1 or 2) corresponding to the image that best represented the sentence prime. The experiment was divided into three continuous phases; a set of conscious trials, an SOA setting stage to establish subjective thresholds, and a set of subliminal trials.

Conscious trials. Once the participant had read the presented instructions, the procedure for the conscious trials began with a set of 6 practice trials. The verbs and schematic images used in all practice trials were different from those used in experimental conscious and subliminal phases. Following the presentation of the fixation cross, the active or passive sentences were presented on the screen for 350 ms to ensure conscious visual perception. Programming in E-Prime ensured that the offset of the stimulus sentence was immediately followed by the onset of the backward mask in all experimental trials, with this being especially important in preventing conscious perception in subliminal trials. With the offset of the mask, participants were presented with the two image choice, in which one image depicted A as active, and the other depicted B as active. The participant was expected to press either the "1" or the "2" key on the keyboard, depending on whether the first or second image best represented the sentence prime. The two images remained on the screen until the image choice had been made, at which point the next trial proceeded after a 250-ms pause. Having completed the set of 6 practice trials, participants were instructed to continue on to the experimental conscious trials with the conscious trials replicating the exact procedure used in practice trials. Participants completed one block of 32 randomly presented trials, with an emphasis on accuracy as opposed to speed. Participants were not informed whether their image choice was correct or incorrect. Having completed the conscious trials, participants viewed the list of 12 verbs to be used in subliminal trials. Each verb was presented on the center of the screen for 1,500 ms, with a 100-ms pause between each verb, with the list of verbs being presented twice.

SOA setting. The SOA of each participant was tested to ensure individual subjective thresholds for subliminal perception. Once the conscious trials were completed, the participants moved on to the SOA setting phase. The task format replicated that used in conscious trials; participants were presented with a fixation cross, prime sentence, a backward mask and then the two image choice. Once the participants had chosen the image they believed represented the prime sentence, they were required to rate, on a scale of 50–100%, how confident they were that they had chosen the correct image; 100% would suggest that the participants knew which image to choose, and 50% would suggest that they were purely guessing. If during the SOA setting phase a participant rated confidence to be anything above 50%, stimulus duration was reduced by 16 ms after each trial from a starting presentation duration of approximately 140 ms. Once a participant had rated confidence to be at 50% (just guessing), the SOA remained at that same presentation duration for the following trials. Once confidence had been rated at 50% (chance performance) for five successive trials, the SOA setting phase finished and the participant moved on to the subliminal phase of the experiment. If during any of those five trials participants rated anything above 50%, the SOA was again reduced until the participant rated confidence to be at 50% for five successive trials. If a participant reached minimum stimulus presentation duration (16 ms) while still rating confidence to be above 50%, they were excused from the experiment.[1] Before the SOA setting phase began, participants completed a set of 6 practice trials to accustom themselves to the confidence procedure. For these practice trials, stimulus presentation was held at 140 ms. As with all phases, practice stimuli differed from experimental stimuli.

Subliminal trials. After participants completed the SOA setting phase, subliminal trials commenced with no further practice trials. The 96 subliminal trials were divided into two blocks of 48 trials, allowing the participant to pause between blocks. For the subliminal trials, prime sentence duration was determined by the point at which participants had rated confidence to be at 50% for five successive trials. As research has suggested that individual visual thresholds for subliminal stimuli may vary from initial threshold setting to experimental testing, or even on a trial by trial basis as a result of illumination levels and dark adaptation (Holender, 1986), confidence ratings for image choice were again required after each subliminal trial (an improvement on the block by block confidence ratings of e.g., Cheesman & Merikle, 1984, 1986). To prevent rhythmic pressing of the "1" or the "2" keys, and to remind participants of the task required, each block of 48 subliminal trials additionally contained 10 randomly placed conscious trials (at a presentation duration of 350 ms) using different stimuli from the subliminal trials (cf. Eimer, Kiss, Press, &

[1] One participant reached minimum stimulus presentation of 16 ms while still rating confidence to be above 50% during the SOA setting phase. The participant, whose data on the initial phases of the experiment were removed from further analysis, was excused from the experiment before reaching the subliminal phase.

Sauter, 2009), creating two blocks of 58 trials. After completion of the experiment, participants were thanked and fully debriefed. Each participant received an information sheet giving some background information on the study as well as providing experimenter details.

Results

SOA setting. Subjective threshold durations ranged from an SOA of 16 ms to 80 ms, with an average experimental subliminal presentation speed of 48 ms ($SD = 15.24$).

Trial accuracy. It was expected that for the conscious phase of the experiment, participants would choose the correct schematic image on close to 100% of trials for both active and passive sentences. The mean number of correct identifications for conscious trials was slightly off 100% ($M = 93\%$, $SE = 1$). For the sentence primes in which A or B was active, mean correct identification averaged 94% ($SE = 1$), whereas correct identification in passive sentence primes averaged 93% ($SE = 1$). For the subliminal trials, only those trials in which participants rated confidence to be 50% (i.e., guessing) were included in the analysis. Of the 96 subliminal trials, the number upon which each participant rated confidence to be above 50% ranged between 0 and 20 trials ($M = 10$, $SD = 6$). For all statistical tests, we used an alpha level of .05 to determine significance. Accuracy on subliminal trials ($M = 51\%$, $SE = .8$) did not significantly differ from what would be expected by chance, $t(29) = 1.49$, $p = .15$, $d = 0.55$. When the accuracy of active ($M = 52\%$, $SE = 1$) and passive ($M = 51\%$, $SE = 1$) subliminal sentences were analyzed individually, neither active, $t(29) = 1.59$, $p = .12$, $d = 0.59$ nor passive, $t(29) = .49$, $p = .63$, $d = 0.18$ conditions significantly differed from chance performance. Discrimination was also assessed in terms of (logistic) d', which did not significantly differ from zero, $M = .05$, $SE = .04$, $t(29) = 1.49$, $p = .15$, $d = 0.55$.

However, we were unable to determine from this nonsignificant trial accuracy result whether this implied that there was evidence for the null hypothesis (i.e., that trial accuracy was at chance performance), or that there was no evidence of any conclusion (Dienes, 2011). To determine whether there was evidence for the experimental hypothesis (i.e., that trial accuracy would be above chance performance), we instead used a Bayes factor. Although values under 1/3 are considered evidence in support of the null hypothesis, values of 3 and over are considered substantial evidence in support of the experimental hypothesis, and values in between 1/3 and 3 indicate that the data are insensitive (Dienes, 2011; Jeffreys, 1961). Armstrong and Dienes (2013; Experiment 3) used the same presentation conditions and showed a 5% effect of processing subliminal negation. That task should have roughly the same difficulty as the current task. Thus, to represent the plausibility of different possible population effects, we used a half-normal with a standard deviation of 5% (following the recommendation of Dienes, 2011, Appendix). A sample mean of 1% above baseline ($SE = .8$), led to a Bayes factor of $B = 0.60$, indicating the data were insensitive and did not discriminate between the hypothesis of a subliminal effect and the null hypothesis.

Response time. The time taken to identify the schematic image that best represents the sentence prime was recorded for both conscious and subliminal active and passive conditions. For the conscious trials, a paired sample t test suggested that on average, participants were significantly quicker to identify the schematic image in active conditions ($M = 2272$, $SE = 281$) when compared with passive conditions, $M = 2764$, $SE = 279$, $t(29) = -3.42$, $p = .002$, $d = 1.27$. For the subliminal trials, participants were also significantly quicker to identify the schematic image for active conditions ($M = 2118$, $SE = 251$) when compared with the passive condition, $M = 2346$, $SE = 277$, $t(29) = -2.68$, $p = .02$, $d = 0.99$.

Discussion

For the conscious trials, correct identification of the image averaged at 93–94%. When required to choose the correct image in subliminal conditions, correct identification averaged at 52% for active sentence primes, and 51% for passive sentence primes, with this image identification not being significantly above chance expectations. A Bayes factor indicated that the data were insensitive and cannot be taken as providing strong support for the null hypothesis.

However, support for the unconscious processing of subliminal verb voice was provided by the RT data. Although the participants were told that emphasis was placed on accuracy as opposed to speed, it was nevertheless interesting to analyze RTs. According to Miller (1962) and Chomsky (1965), passive sentences require more time consuming processing than do active sentences. In order to arrive at the semantic representation of the sentence, the passive form needs to be transformed into its basic structure, or "kernel," to determine who or what is the agent. Here, the basic kernel sentences are the active forms (e.g., "A injects B"), with the passive forms (e.g., "B is injected by A") being a derivative of these kernel sentences. Understanding of these passive sentences is then gained through the use of a passive transformation. The average 492-ms RT difference evidenced in conscious trials supports this and additional research demonstrating the difference in cognitive difficulty between understanding active versus passive sentences (e.g., Gough, 1965, 1966). We found it even more interesting that this RT difference between active and passive primes was similarly evidenced in subliminal conditions, with participants being on average 228 ms faster to identify the image in active conditions when compared with passive conditions.

The use of the guessing criterion for establishing subliminal perception could be criticized on the grounds that participants come with different interpretations as to what "guess" means. However, in the instructions, and on each screen shot when participants were required to rate confidence, they were given a definition of what "guessing" (and "know") means. The participants were told to give a value of 50% if they believe that they were purely guessing; that they had no idea which word to choose and that they may as well have tossed a coin. They were also told that if they had any confidence at all, if they believed they saw anything of potential relevance at all, they were to give a value above 50. Poorly defined end points on a confidence scale can render the guessing criterion meaningless; thus, the instructions precisely defined the required concept of "guess."

Therefore, using individual subjective thresholds of measuring subliminal perception (Cheesman & Merikle, 1984), the results of Experiment 1 do not indicate one way or another whether people are able to correctly identify the image for active and passive primes beyond chance performance. However, the significant results evidenced in the RT data suggests that the subliminal priming of active versus passive sentences warrants further investigation. Because research has demonstrated that the type of mask used, more specifically, the use of letter strings or symbols (e.g., ampersands and hatch marks), can negatively influence the cognitive processing of subliminal stimuli due to phoneme, grapheme and sematic interference (Di Lollo, Enns, & Rensink, 2000; McClelland, 1978; Perfetti & Bell, 1991; Walley & Weiden, 1973), Experiment 2 aimed to develop a more sensitive method of presenting subliminal stimuli.

Experiment 2

Experiment 2 adopted a gray-scale contrast method of masking established by Lamy, Mudrik, and Deouell (2008). This method uses a prime that is presented in gray, within a background of gray at a slightly different contrast level. This method allows a considerably longer exposure of the prime without the use of backward masking. As in Experiment 1, it was expected that for the conscious trials, participants would identify the correct schematic image on close to 100% of the trials for both active and passive conditions. In addition, it was hypothesized that participants would identify the correct schematic image for both active and passive conditions beyond chance expectations (that is, beyond 50%) for the subliminal trials. Furthermore, it was predicted that identification of the correct image in the active condition would be faster than in the passive condition for both conscious and subliminal trials.

Method

Design and participants. In a repeated measures design with the number of correct identifications being the dependent variable, 28 undergraduate psychology students from the University of Sussex took part in this study in exchange for course credits. None of the participants took part in Experiment 1.Twenty-one of the participants were female and seven male, with ages ranging from 18 to 24 years (M = 19.43, SD = 1.55).

Apparatus and materials. The experiment was presented on a Dell laptop with a 60-Hz screen refresh rate, and the study was created using E-Prime Version 2.0 (Psychology Software Tools, Inc., Sharpsburg, PA). All materials, sentence primes and verb lists used in Experiment 2 replicated those used in Experiment 1.

Procedure. All participants were tested individually in a private room in which they sat before a laptop such that their eyes were approximately 60 cm from the monitor screen. All participants had normal or corrected to normal vision, and English was the first language for all participants. The experiment followed the same format as used in Experiment 1 in that all participants completed a set of conscious trials, viewed a list of the verbs to be used in subliminal trials, an SOA setting phase, and a subliminal phase.

Conscious trials. The conscious phase contained the same 6 practice trials and 32 randomly placed experimental trials used in Experiment 1. The fixation was in the form of a cross presented within a rectangular box which was centrally presented on the screen for 350 ms, followed immediately by either the active or passive sentence. This sentence was presented within a rectangular box of the same size as used for the fixation, with the background of the rectangle being filled with gray at a contrast level set by equally altering the red, green and blue (RGB) channels to 212 on the computer monitor (background contrast determined by the background contrast used by Lamy et al., 2008). The prime sentence (e.g., "A is injecting B" or "A is injected by B") was presented within this box in gray at an RGB contrast level of 108 (see Figure 3 for an example). The prime sentence was presented for 300 ms to ensure conscious perception, and the sentence was immediately followed by the two images centrally presented on the screen.

SOA setting. For the SOA setting phase, the trials followed the same format used in Experiment 1. In order to render the prime subliminal, each prime sentence was presented at an RGB level of 208 against a background RGB contrast of 212 (an RGB level of 208 against a background of 212 was determined by the mean visual calibrated level for subliminal perception evidenced in Lamy et al., 2008; see Figure 4 for an example). Once the participant had chosen the image that best represented the prime sentence, they were again required to rate how confident they were that they had chosen the correct image on a scale of 50–100%. From a starting presentation speed of 500 ms, stimulus duration was reduced by 16 ms each time a participant indicated any confidence in their image choice.

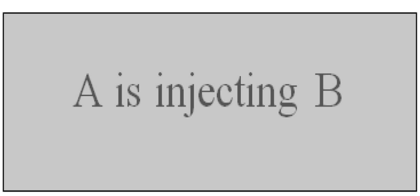

Figure 3. Example of an active conscious contrast prime.

Subliminal trials. The subliminal phase of the experiment contained the same two blocks of 48 trials used in Experiment 1. The prime sentence was presented at the same RGB contrast as used in the SOA setting phase (RGB of 208 against a background contrast of 212), with the presentation of the prime being determined by the point at which the participant rated confidence to be at 50% for five successive trials in the threshold setting phase. Confidence ratings were again taken after each trial. Randomly placed within each block of 48 subliminal trials was an additional 10 conscious trials (with the prime sentence at an RGB of 108 against a background RGB contrast of 212, presented for 300 ms) to prevent rhythmic pressing of the "1" and "2" keys, and to remind participants of the task required (cf. Eimer, Kiss, Press, & Sauter, 2009). After completing the subliminal trials, participants were fully debriefed and received an information sheet giving some background to the study as well as experimenter details.

Results

SOA setting. Subjective threshold durations ranged from an SOA of 32 ms to 176 ms, with an average experimental subliminal presentation duration of 80 ms (SD = 37).

Trial accuracy. As in Experiment 1, it was expected that participants would choose the correct image on approximately 100% of the trials for both active and passive sentences for the conscious phase of the experiment. The mean number of correct identifications for conscious trials was slightly off 100% (M = 93%, SE = 2). For the sentence primes in which A or B was

Figure 4. Example of an active subliminal contrast prime.

active, mean correct identification averaged at 93% (*SE* = 2), whereas correct identification in passive sentence primes averaged at 94% (*SE* = 2). For the subliminal trials, only those trials in which participants rated confidence to be at 50% (i.e., guessing) were included in the analysis. Of the 96 subliminal trials, the number upon which each participant rated confidence to be above 50% ranged between 0 and 57 trials (*M* = 18, *SD* = 12). Accuracy on subliminal trials significantly differed from what would be expected by chance alone, *M* = 53%, *SE* = 1, *t*(27) = 2.73, *p* = .01, *d* = 1.05. Analyzed individually, accuracy on active conditions (*M* = 54%, *SE* = 2) significantly differed from chance expectations, *t*(27) = 2.24, *p* = .03, *d* = 0.86, whereas accuracy on passive conditions (*M* = 51%, *SE* = 1) did not significantly differ from what would be expected by chance alone, *t*(27) = 1.62, *p* = .12, *d* = 0.62. A Bayes factor was determined to assess whether there was evidence within the data to support the experimental hypothesis that accuracy on passive conditions would be above chance level. We used the same half normal with a standard deviation of 5% as in the last experiment. A sample mean of 1% above baseline (*SE* = 1), lead to a Bayes factor of B = 0.53, indicating that the data were insensitive and do not in fact provide strong support for the null hypothesis (Dienes, 2011).

However, a paired sample *t* test compared the percentage of occasions that participants simply chose the picture based on the assumption that the lead-in character was active for both active (*M* = 54%, *SE* = 2) and passive (*M* = 49%, *SE* = 1) conditions. This difference in accuracy was significant, *t*(27) = 2.73, *p* = .01, *d* = 1.05. This result indicates not only knowledge of the lead-in character, but also the unconscious processing of verb voice in active and passive conditions, as only if the verb within the sentences was appropriately processed should there be a difference in choice of the lead character. Furthermore, overall subliminal d' values differed significantly from zero, *M* = .12, *SE* = .04, *t*(27) = 2.72, *p* = .01, *d* = 1.05.

As well as utilizing the guessing criterion to assess subliminal perception, evidence of conscious knowledge was also assessed using the zero-correlation criterion (ZCC) to determine whether there was a relation between confidence and accuracy on trials when the participant rated confidence to be at versus above 50% (the divide between complete guessing and some confidence being the theoretically relevant one for determining the conscious status of knowledge; Dienes, 2004). The difference in accuracy between trials in which the participants were guessing and trials in which confidence was ignored was 0.42%, which was not significant, *t*(27) = −1.57, *p* = .13, *d* = 0.60. In addition, a Bayes factor was conducted to assess whether the data supported the null hypothesis of no relationship between confidence and accuracy or were just insensitive. First, the range of effect sizes expected if there were conscious knowledge needs to be specified. The maximum slope was determined by a method used previously by Armstrong and Dienes (2013); Guo et al. (2013) and Li et al. (2013). The maximum slope was determined by the overall accuracy in Experiment 2 when confidence was ignored (3%) divided by the proportion of confident responses (.19). Therefore, the maximum slope = 16% (see Armstrong & Dienes, 2013, for this method applied in past subliminal perception research and its detailed justification). Using a uniform distribution between 0 and 16 (sample *M* = 0.42, *SE* = .27) produced a Bayes factor of 0.13, providing substantial evidence for the null hypothesis that there was no relation between confidence and accuracy.[2] That is, there was substantial evidence against even partial awareness. The correlation between confidence and accuracy was additionally measured using Type II d'. Type II d' did not significantly differ from zero, *M* = .01, *SE* = .01, *t*(27) = 1.55, *p* = .13, *d* = 0.60. A Bayes factor was

[2] The Kanai, Walsh, & Tseng (2010) index of awareness (the 0-correlation criterion applied just to stimulus-absent trials), which discriminates between perceptual and attentional blindness, is a useful addition to subjective measures but cannot be applied in this case because of the lack of trials in which a stimulus was absent.

conducted to assess whether the Type II data supported the null hypothesis that there was no relation between confidence and accuracy. Given plausible assumptions, Type II d' does not exceed Type I (Barrett, Dienes, & Seth, in press). Thus, the alternative hypothesis that there existed some relation between confidence and accuracy (i.e., some conscious perception) was modeled as a uniform distribution between 0 and the mean Type I d' of .12. The Bayes factor of 0.29 also provided substantial evidence for the null hypothesis.

Response time. The time taken to identify the schematic image that best represented the sentence prime was recorded for both conscious and subliminal active and passive conditions. For the conscious trials, a paired-sample *t* test suggested that on average, participants were significantly quicker to identify the image in active conditions (M = 2244, SE = 280) when compared with passive conditions, M = 3092, SE = 247, $t(27) = -4.53$, $p < .001$, d = 1.74. Furthermore, for the subliminal trials, participants were similarly significantly quicker to identify the image for active conditions (M = 2023, SE = 114) when compared with passive conditions, M = 2367, SE = 140, $t(27) = -2.76$, p = .01, d = 1.06.

Discussion

For the subliminal primes, the average identification of the correct image averaged at 54% for the active condition, and 51% for passive conditions. Therefore, as hypothesized, participants successfully identified the correct image for active conditions beyond what would be expected by chance alone. For the passive conditions, the data were insensitive. However, when the accuracy was compared for the occasions which participants simply choose the image corresponding to the lead-in character (i.e., ignoring the active and passive verb form), correct identification was significantly different. That is, if the participant merely "knew" which character was the protagonist based on which character came first without having processed the voice of the verb, there should not be a significant difference between active and passive conditions. Therefore, only if the active versus passive voice of the verb was appropriately processed should there be a significant difference between conditions.

Furthermore, as found in Experiment 1, participants were significantly faster to identify the image in active conditions when compared with passive conditions. In the conscious phase of this experiment, participants were on average 848 ms quicker to identify the image for active trials when compared with passive trials, and on average 344 ms quicker for subliminal trials. These RTss reflect the difference in cognitive difficulty in understanding active and passive sentences, with the understanding of passive sentences relying on a passive transformation to make sense.

The aim of Experiment 2 was to develop a more sensitive method of presenting subliminal stimuli than used in Experiment 1 by using a gray-scale contrast method of masking established by Lamy et al., (2008). While we have demonstrated potential successful subliminal priming of active sentences, Experiment 2 failed to demonstrate successful subliminal priming of passive sentences. However, superior priming effects can be produced through the use of multiple prime presentations (Atas, Vermeiren, & Cleeremans, 2013; Marcel, 1983b). For example, Wentura and Frings (2005) used objective thresholds of measuring awareness and compared the effectiveness of a single masked prime to a prime that was repeatedly presented 10 times in quick succession. The results suggested that only the repeated presentation of the prime produced a significant priming effect. Therefore, this issue of repeated priming was explored further in Experiment 3.

Experiment 3

Experiment 3 aimed to expand on the results evidenced in Experiment 2 by attempting to develop a more sophisticated method of priming to increase the possibility of successful priming of passive sentences. Wentura and Frings (2005) found a superior priming effect when a prime was presented 10 times in quick succession. Atas et al., (2013) and Marcel (1983b) demonstrated an increasing priming effect when using up to 20 prime repetitions. It is believed that the multiple exposure of the prime has a cumulative effect of strengthening the prime by increasing the total prime duration yet still remaining out of conscious awareness (Wentura & Frings, 2005). Therefore, Experiment 3 continued to utilize the gray-scale contrast method of masking evidenced in Experiment 2 but increased prime exposure to 3 presentations. Armstrong and Dienes (2013) found that an increase from one to three repetitions with the same gray-scale masking as used here may increase subliminal priming by more than 50%.

As evidenced in Experiment 2, we expected that participants would identify the correct image, beyond chance expectations, for active sentence primes. Furthermore, we expected that participants would also choose the correct image for passive conditions beyond chance level performance. In addition, we predicted that identification of the correct image in the active condition would be faster than in the passive condition for both conscious and subliminal trials.

Method

Design and participants. One of the problems with the previous study was low power. The d_z for the accuracy on passive trails was 0.3 in the previous experiment. Given that repeating the prime may increase the effect by 50% (Armstrong & Dienes, 2013), we would be attempting to pick up an effect size of $d_z = 0.45$. For a power of 80%, a sample size of 40 is needed. In a repeated measures design with the number of correct identifications being the dependant variable, 40 undergraduate psychology students from the University of Sussex took part in this study in exchange for course credits. None of the participants took part in Experiments 1 or 2.Twenty-nine of the participants were female and 11 male, with ages ranging from 18 to 39 years ($M = 20.75$, $SD = 4.95$).

Apparatus and materials. The experiment was presented on a Dell laptop with a 60-Hz screen-refresh rate, and the study was created using E-Prime version 2.0. All materials, sentence primes and verb-lists used in Experiment 3 replicated those used in Experiments 1 and 2.

Procedure. Experimental procedure replicated that of Experiments 1 and 2; with a conscious phase, an SOA setting phase, and the subliminal trials. For the conscious trials, the prime sentences were presented three times, with each presentation remaining on the screen for 250 ms with a 150-ms pause between each presentation. For the SOA setting phase, each of the three presentations of the prime started at a presentation speed of 500 ms, with a 150-ms pause between each presentation. When a participant rated confidence to be above 50%, each of the three prime presentations reduced by one screen refresh (16 ms). For the subliminal trials, prime duration was determined by the point at which participants rated confidence to be at 50% in the SOA setting phase and consisted of the same two blocks of 48 trials, with the additional 10 conscious trials in each block (with the prime sentence at an RGB of 108 against a background RGB contrast of 212, with each of the three presentations at 300 ms).

Results

SOA setting. Subjective threshold durations of the single prime presentation ranged from an SOA of 32 ms to 176 ms (a cumulative range of 96 ms to 528 ms), with an average experimental presentation speed of 64 ms ($SD = 37.05$, with a cumulative mean presentation speed of 192 ms).

Trial accuracy. The mean number of correct image identifications for conscious trials was 94% ($SE = 1$). For the sentence primes in which either A or B was active, mean correct image identification averaged at 95% ($SE = 2$). Correct image identification for passive sentences averaged at 94% ($SE = 2$). For the subliminal trials, only those trials in which participants rated confidence to be at 50% (i.e., guessing) were included in the analysis. Of the 96 subliminal trials, the number upon which each participant rated confidence to be above 50% ranged between 0 and 50 trials ($M = 13$, $SD = 14$). Accuracy on the subliminal trials overall significantly differed from what would be expected by chance alone, $M = 53\%$, $SE = 1$, $t(39) = 3.47$, $p = .001$, $d = 1.11$. Similarly, on subliminal trials, overall d' values significantly differed from zero, $M = .13$, $SE = .04$, $t(39) = 3.47$, $p = .001$, $d = 1.11$. When analyzed individually, accuracy on active prime sentences ($M = 54\%$, $SE = 1$) significantly differed from chance expectations, $t(39) = 3.12$, $p = .003$, $d = 1.00$, whereas accuracy on passive sentence primes ($M = 52\%$, $SE = 1$) did not significantly differ from what would be expected by chance alone, $t(39) = 1.86$, $p = .07$, $d = 0.60$. However, a Bayes factor was determined to assess whether there was evidence within the data to support the experimental hypothesis that accuracy on passive conditions would be above chance level. We used the same half normal with an *SD* of 5% as before. A sample mean of 2% above baseline ($SE = 1$), lead to a Bayes factor of B = 2.61, providing weak evidence to support the experimental hypothesis that accuracy in passive conditions was above chance performance.

In addition, a paired sample *t* test compared the percentage of occasions that participants simply chose the picture based on the assumption that the lead-in character was active for both active ($M = 54\%$, $SE = 1$) and passive ($M = 48\%$, $SE = 1$) conditions. This difference in accuracy was significant, $t(39) = 3.47$, $p = .001$, $d = 1.11$. As evidenced in Experiment 2, this result indicates the unconscious processing of verb voice in active and passive conditions, as only if the sentence was appropriately processed should there be a difference in accuracy of image choice.

As in Experiments 1 and 2, conscious knowledge was again assessed by ZCC. The difference in accuracy between trials in which the participants were guessing and trials in which confidence was ignored was 0.27%, which was not significant, $t(39) = -1.14$, $p = .26$, $d = 0.37$. In addition, a Bayes factor was conducted to assess whether the data supported the null hypothesis that there was no relationship between confidence and accuracy in Experiment 3. The maximum slope was determined by the overall accuracy in Experiment 3 when confidence was ignored (3%) divided by the proportion of confident responses (.13). Therefore, the maximum slope = 23%. Using a uniform distribution between 0 and 23 (sample $M = 0.27$, $SE = .24$) produced a Bayes factor of 0.04, providing substantial evidence for the null hypothesis that there was no relation between confidence and accuracy. That is, the knowledge was entirely unconscious by subjective measures. Type II d', another way of measuring the ZCC, did not differ significantly from zero, $M = .01$, $SE = .01$, $t(39) = 1.04$, $p = .31$, $d = 0.33$. Using a uniform distribution between 0 and the mean Type I d' of .13 (sample $M = .01$, $SE = .01$) produced a Bayes factor of 0.27, also providing substantial evidence for the null hypothesis.

Response time. The time taken to identify the schematic image that best represented the sentence prime was recorded for both conscious and subliminal active and passive conditions. For the conscious trials, a paired-sample *t* test suggested that on average, participants were significantly quicker to identify the image in active conditions ($M = 2307$, $SE = 130$) when compared with passive conditions, $M = 2797$, $SE = 116$, $t(39) = -3.42$, $p = .001$, $d = 1.10$. Furthermore, for the subliminal trials, participants were similarly significantly quicker to identify the image for active conditions ($M = 2075$, $SE = 95$) when compared with passive conditions, $M = 2390$, $SE = 142$, $t(39) = -2.14$, $p = .04$, $d = 0.69$.

Discussion

The average accuracy rate for the correct image identification in subliminal trials was 54% for the active condition and 52% on passive conditions. As expected, participants identified the correct image beyond chance expectations for active conditions. While the 2% above-baseline performance for subliminal passive trials was an improvement on the performance rate evidenced in Experiments 1 and 2, this was not significant. However, as evidenced in Experiment 2, there was a significant difference between active and passive conditions when the verb form was ignored. Hence if the participant merely saw the lead-in character letter and choose the image accordingly, there should not be a difference in accuracy between active and passive conditions. Furthermore, participants were significantly faster to identify the image in active conditions when compared with passive conditions for both conscious and subliminal trials. During the conscious phase, participants were an average 490 ms faster to identify the image in active conditions. For the subliminal trials, participants were on average 315 ms faster. Therefore, despite awareness of the prime sentence being outside of subjective conscious perception, the RT difference nevertheless reflects the difference in cognitive difficulty in understanding active versus passive sentences.

General Discussion

The present research aimed to investigate the extent of subliminal perception by attempting to determine whether unconscious processing was able to distinguish between active and passive sentences. In a series of three experiments, participants were subliminally presented with a textual sentence in which the verb form denoted whether one of two characters (A or B) was active or passive. Participants were subsequently presented with two schematic images, one image of which depicted character A as active and the other depicting character B as active, and asked to judge which image best represented the sentence prime. If the correct image was chosen beyond chance expectations, this would provide evidence to demonstrate the cognitive processing of verb voice outside of subjective conscious awareness.

Experiment 1 attempted to demonstrate successful subliminal priming using the traditional method of backward masking to render the prime sentence subliminal. Using this method, the prime sentence was followed by a string of ampersands to block conscious perception of the prime. The results of Experiment 1 did not provide sensitive data to determine if people were able to identify the correct image beyond chance expectations for either active or passive subliminal conditions. As prior research has suggested that the use of letter strings or symbols such as the ampersands used in Experiment 1can adversely affect the cognitive processing of textual primes due to interference during phoneme and grapheme interpretation (Di Lollo, Enns, & Rensink, 2000), Experiment 2 aimed to develop a more sensitive method of masking the subliminal primes. This was achieved by adapting the gray-scale contrast method of masking employed by Lamy et al., (2008). The results suggested that participants were able to correctly identify the image representing the prime sentence beyond chance expectations for active conditions, and that participants could distinguish active from passive conditions. In addition this knowledge was shown to be entirely unconscious by the ZCC (Dienes, 2004), so partial awareness was not responsible for the effect (Kouider & Dupoux, 2004).

Both Wentura and Frings (2005) and Marcel (1983b) have provided evidence to suggest that the multiple presentation of a subliminal prime is more effective than the standard single prime presentation due to cumulative exposure. Therefore, in Experiment 3, methodological procedure replicated that evidenced in Experiment 2 with the exception that the participant was presented with 3 repetitions of the prime sentence in quick succession. The results of Experiment 3 suggested that, as evidenced in Experiment 2, participants were able to correctly identify the image representing the prime sentence beyond chance expectations for active conditions; further, participants could once again distinguish active from passive conditions. Furthermore, a Bayes factor using the ZCC provided strong evidence in support of the null hypothesis that there was no relation between confidence and accuracy: All knowledge appeared unconscious.

Although we argue that the accuracy results evidenced in Experiments 2 and 3 demonstrated the potential for unconscious cognition to comprehend verb voice, it could be argued that success was instead determined by simple processing of prime length or the presence or absence of "by." That is, shorter primes (e.g., "A is injecting B" vs. "A is injected by B") indicated active conditions in the same way that the absence of "by" indicated active. However, without at least an awareness of the lead-in character (or indeed the final character), knowledge of prime length or identification of "by" would have been insufficient to correctly identify the schematic image when presented with a choice of images depicting characters A and B as both active and passive. It is possible that participants learned to attend to the final letters of the prime (i.e., "by B" vs. "B") which would inform them of which image to choose. However, though not as sophisticated as the full unconscious analysis of verb voice, this would nevertheless demonstrate the processing of the syntactic functioning of two word primes (lead in character/final character, and "by").

Similarly, it could be argued that successful priming evidenced in active conditions could indicate simple priming of the lead-in character. That is, processing the first word (i.e., character) and indicating the corresponding picture in which the lead-in character was active would allow success on the active trials without actually necessitating the processing of verb voice. However, if this were the case, there would be no differences between active and passive conditions in the percentage of occasions that participants choose the image depending on simply which character came first. Yet, the results of both Experiments 2 and 3 found a significant difference in image choice between active and passive conditions, therefore indicating differential processing of verb voice.

Nonetheless, it could still be argued that the performance in the active condition was produced by word priming from the first position (which subjects had learnt to attend to from conscious trials) and the greater complexity in the passive condition disrupted even word priming and participants performed at chance. Such a theory needs to explain why for example, "is injecting" is less complicated than "is injected by" without postulating the semantic or syntactic processing of word combinations as such. The simplest answer could be the relevance of the number of words. That is, the first noun can be processed when there are four words displayed, but not five (cf. the decrement in priming by additional words found by Kahneman & Henik, 1981). One way of testing this theory is to compare "is injecting" with "injected by" in the same paradigm that we have otherwise used. If it is a matter of simple word priming then by making the display more simple, participants should classify below chance levels in the passive condition. If subjects process the voice of the verb, they should classify at above-chance levels. However, we need not run this further experiment to settle the question; we can provide evidence with the existing data by a meta-analysis over the three experiments. The overall mean accuracy for the passive condition was 51%, with a standard error of 0.4, which is significantly above baseline, $t(97) = 2.26$, $p = .03$, $d = 0.46$, and a meta-analysis for the active condition revealed a mean performance level of 53.2% with a standard error of .77, $t(97) = 4.14$, $p < .001$, $d = 0.84$. Both of these tests remained significant after applying Hochberg"s (1988) sequential Bonferroni correction. Thus, taken as a whole, the set of three experiments provides compelling evidence for the subliminal processing of active-versus-passive voice.

Further evidence to support the argument that participants were able to cognitively process verb voice outside of conscious awareness was provided by the RT data. Miller (1962) and Chomsky (1965) have argued that passive sentences are more difficult to comprehend when compared with active sentences as they require more extensive processing. This processing results from the need to participate in a passive transformation in order to return the sentence to its basic structure, of which the passive sentence is a derivative. The RT difference evidenced in conscious trials in all experiments supports this and other research (e.g., Gough, 1965, 1966) by demonstrating that participants were significantly quicker to choose the image when the sentence prime was active compared with passive for conscious trials. Over all three experiments, participants were on average 610 ms faster. Of even more interest, this difference in RT was also evidenced in subliminal trials. Across, all three experiments, participants were on average 274 ms faster to identify the image in active conditions when compared with passive conditions. Similarly, a meta-analysis indicated an overall significant result for the RT difference in all subliminal conditions ($p < .001$).[3] This significant result lends further support to the unconscious processing of verb voice in subliminal active and passive conditions.

We used subjective methods (the guessing criterion; and the zero correlation criterion supported by Bayes factors to interpret nonsignificant results) to establish the subliminal nature of the stimuli. The use of the guessing criterion in measuring subliminal perception is often criticized on the grounds that participants may have differing interpretations as to what "guess" means. Poorly defined end points on a scale of confidence can render the guessing criterion meaningless; thus, the instructions precisely defined the required concept of "guess."

If we had used objective measures, that is, the ability of the participant to discriminate the content of what was displayed, the perception would be declared conscious, because that is exactly what participants did: They could pick the right picture. On the one hand, these results illustrate the usefulness of subjective rather than objective measures in determining the full richness of unconscious processing. On the other hand, our argument could be turned on its head, and the skeptic declare that we had not established subliminality rigorously enough, because it is only objective measures that convince the skeptic. As objective rather than subjective measures pick out fewer cases as being genuinely subliminal, using objective measures is

[3] A meta-analysis conducted on all RT differences between subliminal active and passive conditions ($M = 274$, $SE = 63$) revealed a significant relationship, $t(95) = 4.33$, $p < .001$, $d = 0.89$.

more convincing. In other words, we should aim to minimize the rate at which we make Type I errors (false alarms concerning subliminal perception). The problem with the strategy of minimizing Type I errors is that it requires indefinitely strong evidence to make a case, combined with a 100% miss rate no matter what the evidence is. Even though sometimes it may be scientifically useful to seek to minimize one error type, a useful general strategy is to try to minimize total errors by balancing the two error types. That is, the goal may not to be to convince the skeptic no matter what, but to get the most unbiased measure of a phenomenon (so that we can determine its properties for the development and testing of models).

Objective measures, to be unbiased, presume the "worldly discrimination" theory of consciousness, namely that, the content directly expressed in any behavior (e.g., pointing to where a dog is; Dienes & Seth, 2010a) is the content of a conscious mental state (e.g., consciously knowing "There is the dog!") Thus, according to worldly discrimination theory a person shows that they are consciously aware of a feature in the world when they can discriminate it with choice behavior. By contrast, the more common theories of consciousness that are variants of higher order theories or global workspace/integration theories would not endorse the claim that simple discrimination implies conscious awareness (e.g., Baars, 2002; Lau & Rosenthal, 2011; Seth et al., 2008; Timmermans, Schilbach, Pasquali, & Cleeremans, 2012). Rather, according to both these latter classes of theory, a person who consciously sees would be able to indicate they see specific content rather than guess it when probed about whether they are seeing it; that is, the conscious status of the seeing would be revealed by appropriate subjective measures. According to these theories, the measures we used were at least the right sort of measure to use.

According to yet another class of theory, brain activity in specific local areas (perhaps with local recurrence) generates phenomenal consciousness. Thus, conscious perception can co-occur with the sincere and earnest denial of perceiving - and even perhaps when a person cannot discriminate what was there (e.g., Block, 2009). According to such theories in the current studies we have not measured whether perception was conscious or unconscious per se, but whether perception involved reflective or introspective consciousness. But on all accounts, we have measured the sort of consciousness that comes with the accurate expression of higher order thoughts when a person is probed. We have explored the limits of unconscious perception when unconscious seeing means not being aware that one saw anything relevant. Investigating the limits of processing with and without this metacognitive capacity is an interesting empirical question, no matter what labels are used.

Rather than asking participants if they saw anything relevant, one can ask if they had any visual experience of the stimulus whatsoever (Ramsøy & Overgaard, 2004; Sandberg et al., 2010). For example, what is the extent of subliminal processing when people do not believe they even saw a flash? Using our confidence ratings, people may have been aware of seeing a flash of the prime, they just had no conscious experience of content relevant to the judgment. If so, the relevant content used in the judgment was unconscious (Dienes & Seth, 2010b). Nonetheless, future studies could explore the relation between different conscious visual contents (e.g., "a flash") and the complexity of subliminal processing allowed.

We made use of both the guessing and zero correlation criteria of unconscious knowledge. The guessing criterion allows the conclusion that some knowledge was unconscious but leaves open whether in addition there was some conscious knowledge. The zero correlation criterion tests whether there was any conscious knowledge, with the absence of conscious knowledge resulting in a nonsignificant relation between confidence and accuracy (where that relation can be expressed as a correlation, slope, difference or Type II or meta d', see, e.g., Dienes, 2007; Maniscalco, & Lau, 2012; Mealor & Dienes, 2012). However a nonsignificant result in itself does not distinguish between (a) insensitive data and (b) evidence in support of the null hypothesis. Obviously, the zero correlation criterion in order to legitimate the conclusion of unconscious knowledge requires evidence in favor of the null hypothesis—not insensitive data. A Bayes factor is required to make the distinction between insensitive data and evidence in favor of the null hypothesis. Thus, wherever we obtained nonsignificant zero correlation criteria, we analyzed with a Bayes factor, using methods employed previously by Armstrong and Dienes (2013); Guo et al. (2013), and Li et al. (2013).

Naccache and Dehaene (2001) have argued that although the majority of priming studies have focused on the ability to derive semantic understanding from subliminal stimuli, the possibility of manipulating this semantic comprehension has largely been ignored. Therefore, the current research attempted to determine whether the information contained in a short subliminal sentence could be translated to a schematic representation. If successful, this would demonstrate not only the semantic understanding of active and passive verb form, but also the ability to manipulate this information and translate it into a pictorial image. The trial accuracy data suggested that participants were indeed able to translate the prime sentence into a schematic image for active conditions. Furthermore, both the difference evidenced between the percentage of occasions participants choose the image corresponding to the protagonist and the RT data similarly suggests that participants were able to at least process the distinction in verb voice between active and passive sentences.

Conclusion

To conclude, we presented a series of three experiments that attempted to subliminally prime active versus passive sentences using individual subjective thresholds of conscious awareness. Past research investigating the extent of subliminal priming has tended to focus on the ability to derive semantic understanding from subliminal stimuli. We hoped to demonstrate that in addition to semantic comprehension of active versus passive, participants would be able to successfully manipulate that comprehension by translating into a visual schematic representation. Our results indicate that under subliminal conditions, participants are able to identify the correct image for both active and passive verb forms beyond mere chance expectations. In sum, despite the passivity some have claimed for the unconscious, it can be as active as it is passive.

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