Consciousness and Cognition 37 (2015) 44–56

Contents lists available at ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

Unconscious biases in task choices depend on conscious expectations

Carlos González-García, Pío Tudela, María Ruz *

Department of Experimental Psychology; Mind, Brain and Behavior Research Center, University of Granada, Granada, Spain

ARTICLE INFO

Article history:
Received 2 December 2014
Revised 8 June 2015
Accepted 4 August 2015
Available online 13 August 2015

Keywords:
Non-conscious bias
Consciousness
Task-set selection
Decision-making
Cognitive control
Objective and subjective unawareness

ABSTRACT

Recent studies highlight the influence of non-conscious information on task-set selection. However, it has not yet been tested whether this influence depends on conscious settings, as some theoretical models propose. In a series of three experiments, we explored whether non-conscious abstract cues could bias choices between a semantic and a perceptual task. In Experiment 1, we observed a non-conscious influence on task-set selection even when perceptual priming and cue-target compound confounds did not apply. Experiments 2 and 3 showed that, under restrictive conditions of visibility, cues only biased task selection when the conscious task-setting mindset led participants to search for information during the time period of the cue. However, this conscious strategy did not modulate the effect found when a subjective measure of consciousness was used. Altogether, our results show that the configuration of the conscious mindset determines the potential bias of non-conscious information on task-set selection.

1. Introduction

Several subliminal priming studies have shown that non-conscious representations have a pervasive influence on information processing (e.g. Dehaene & Changeux, 2011; Dehaene & Naccache, 2001; Kiefer, 2012; Kouider & Dehaene, 2007; Marcel, 1983; Mattler, 2003; Peirce & Jastrow, 1884; Ruz, Madrid, Lupiáñez, & Tudela, 2003; Sidis, 1898; Stroh, Shaw, & Washburn, 1908). Data from blindsight or neglect patients have provided similar results (Dehaene & Naccache, 2001; Weiskrantz, 2009). Traditionally, certain high-level processes including cognitive control were considered immune to subliminal information (Dehaene & Naccache, 2001; Hommel, 2007; Kunde, Reuss, & Kiesel, 2012; Schneider & Shiffrin, 1977; Van Gaal, de Lange, & Cohen, 2012). However, various recent studies showing that non-conscious information can influence control processes have challenged this classic idea. Some of these control processes include shifts of attention (Ansorge & Horstmann, 2007; Ansorge, Horstmann, & Scharlau, 2010, 2011), task switching (Ansorge, Kunde, & Kiefer, 2014), response inhibition, conflict monitoring, error detection (Van Gaal & Lamme, 2012), and lastly decision-making (Van Gaal et al., 2012).

Volition and cognitive control models often relate decision-making to task-set selection (i.e. 'what decisions' in Haggard's model; 2008). In the laboratory, this process has been studied using task cueing paradigms (e.g. Schlaghecken & Eimer, 2004). In the subliminal priming field, the main hypothesis is that non-conscious information modulates task selection and affects later stages of the decision process. Two initial studies explored this idea in simple perceptual choices (Kiesel et al., 2006; Schlaghecken & Eimer, 2004). In such studies, participants responded to the direction (i.e. left vs. right) of arrows

* Corresponding author.
E-mail addresses: cgonzalez@ugr.es (C. González-García), tudela@ugr.es (P. Tudela), mruz@ugr.es (M. Ruz).

http://dx.doi.org/10.1016/j.concog.2015.08.001
1053-8100/

that in some trials were preceded by additional masked arrows. Schlaghecken and Eimer (2004) found a bias to respond against the direction of the prime in long mask-target intervals, while Kiesel et al. (2006) observed a tendency to respond in the same direction as the masked arrows. Likewise, in a similar setting, Mattler (2003, 2005, 2006, 2007) showed that presenting cue-congruent masked shapes led to faster execution of the cued task. These results suggest that non-conscious information influenced participants' decisions. However, as other authors have highlighted (Reuss, Kiesel, Kunde, & Hommel, 2011), at least the results obtained by Kiesel et al. (2006) and Mattler (2003), Mattler (2006) could be explained without appealing to a non-conscious bias of decision-making. For example, perceptual priming could have enhanced target processing when it was preceded by a cue with a similar shape appearing at the same location. This explanation does not require cognitive control, as the mere presence of a cue automatically may have triggered the mobilization of attention to the target (Reuss et al., 2011). The same explanation could also be applied to similar studies (Lau & Passingham, 2007; Mattler, 2003). An alternative explanation is that of cue-target compounds. In some of those experiments (Reuss et al., 2011; Exp. 1; Schlaghecken, Klapp, & Maylor, 2009), although cues and targets differed in shape, there was a limited number of target stimuli. Thus, participants may have encoded an explicit response in their episodic memory for specific cue-target combinations (Logan & Bundesen, 2004) that may later have been triggered in a non-conscious manner without requiring any kind of cognitive control.

A recent study on task switching (Reuss et al., 2011; Exp. 2) overcame the shortcomings of explanations provided in terms of cue-target compounds by using transition cues. The design consisted of pairs of two trials: whereas participants were conscious of the first trial, which specified what they should do, the beginning of the second trial was a transition cue, indicating whether they had to repeat the previous task or switch to the other one. This design avoided cue-target compounds because cues were not linked to specific targets or responses. Crucially, transition cues were presented in a conscious or non-conscious manner. Results showed that participants performed the task instructed by the transition cue to a larger extent, even when it was non-conscious, suggesting that task sets could be non-consciously activated in situations where perceptual facilitation and cue-target compound effects were excluded. Nevertheless, in this paradigm the non-conscious cue was always preceded by a conscious task cue, which may have affected the pattern of data. In fact, a repetition effect was found, showing that participants repeated the task of (conscious) trial $n - 1$ in 65% of the trials, regardless of the task signaled by the non-conscious cue. These results suggest a significant influence of a previous conscious task set on *free* decisions. However, it is still not known whether the choice between two tasks can be non-consciously biased even without a previous conscious task cue.

1.1. Influence of conscious expectations on non-conscious information

A number of recent approaches agree on the idea of cognitive control as a set of processes that operate in a ballistic manner once they have been configured by attention and task set. Under this assumption, cognitive control must be configured properly for non-conscious automatic effects to take place. Kiefer and Martens (2010) put these ideas together in their *Attentional Sensitization Model* (later extended to different areas of unconscious cognition in Kiefer, Adams, & Zovko, 2012), according to which a given conscious task setting enhances task-relevant automatic processes but attenuates task-irrelevant ones. They considered that the conscious setting is built upon stimulus expectations and action intentions that mobilize attentional resources accordingly. Several data fit with this model (Chiu & Aron, 2014; Kiefer, 2012; Kiefer & Brendel, 2006; Kiefer & Martens, 2010; Kiefer et al., 2012; Naccache, Blandin, & Dehaene, 2002). Although the influence of conscious task setting on non-conscious biasing of task-set selection has been suggested (Schlaghecken & Eimer, 2004), this hypothesis remains untested.

1.2. Objective and subjective thresholds of consciousness

The studies reviewed so far share a common feature: the presentation time of the masked items is extremely brief. Indeed, they operate in the so-called objective threshold (OT) of consciousness, in which participants' performance is at chance levels when they discriminate between masked stimuli (Holender, 1986). This objective state of unawareness (OU) requires extremely brief stimulus presentation times and does not rely on subjective reports, so it is considered a conservative estimation of unawareness. Since it leads to more compelling positive results (Merikle, Smilek, & Eastwood, 2001), its use is preponderant in current literature (Overgaard, Timmermans, Sandberg, & Cleeremans, 2010). Thus, in our study we aimed at assessing the role of conscious expectations in objectively non-conscious biases towards task choices. We expected this to allow us to compare our results with previous ones, and to test for non-conscious effects under strict visibility conditions. Nevertheless, despite the major acceptance of objective measures, some data suggest that they underestimate the influence of non-conscious information (Merikle & Reingold, 1998) or that they explore a degraded state of non-conscious cognition (Armstrong & Dienes, 2013). Techniques based on subjective reports, on the other hand, provide an alternative or complementary approach.

The subjective threshold (ST) of consciousness assesses awareness based on participants' subjective reports. Participants who are in a subjective state of unawareness (SU) are considered to be non-conscious when they report not being able to perceive a given stimulus (Merikle et al., 2001). This way of testing consciousness fits better than other methods with the notion of consciousness of some theoretical models (Lau & Rosenthal, 2011; Rosenthal, 2008) and philosophical claims (Chalmers, 1996; Dennett, 2003, 2007). Although the usefulness of subjective indexes has been extensively discussed, their actual use has been partially neglected in the literature (see Sandberg, Timmermans, Overgaard, & Cleeremans, 2010). However, some studies conducted in the last few years have shown the unique nature of the SU as a proper non-conscious state rather than a weaker conscious phenomenon (Armstrong & Dienes, 2013; Overgaard et al., 2010; Sandberg, Bibby, Timmermans, Cleeremans, & Overgaard, 2011; Sandberg et al., 2010; Snodgrass & Shevrin, 2006). According to some authors (Snodgrass, Bernat, & Shevrin, 2004; Snodgrass & Shevrin, 2006), objective and subjective thresholds index different types of unawareness. Specifically, they consider that a stimulus under the OU is both phenomenally (that is, perceptually, in Snodgrass' framework) and reflectively unconscious. This reflective consciousness refers to a "higher-order metacognitive process involving reflecting upon and evaluating various phenomenal contents" (Snodgrass & Shevrin, 2006). By contrast, SU stimuli are considered to be phenomenally conscious but again reflectively unconscious. Crucially, the output of this configuration is a state of unawareness qualitatively different from OU but also from awareness (i.e. conscious awareness; CA). So far, the effect of a conscious setting on non-conscious processing has been studied under OU conditions. However, to the best of our knowledge, there is no previous empirical evidence regarding the influence of conscious expectations on SU stimuli. Since under SU conditions the (first-order) representation of the stimulus is relatively intact, we hypothesized its processing to be independent of (higher-order) conscious strategies, namely expectations, as it has been previously suggested: "stimuli [under SU] are typically ignored, but nonetheless exert various influences unnoticed and unmodified by reflective consciousness and its tools (i.e. higher-level response strategies)" (Snodgrass & Shevrin, 2006).

2. Experiment 1

In this first experiment, we sought to replicate previous results on non-conscious modulation of task selection using a novel paradigm. Here, single cues instructed participants to perform one of two different tasks. Whereas participants had to follow the instructions of the cues they perceived consciously, they were told that in some trials there would not be any informative cue and that in those trials they should freely choose between the two tasks. Based on previous studies (Reuss et al., 2011), we predicted that even cues presented at OU would bias participants' choices.

2.1. Method

2.1.1. Participants

Twenty-four students of the University of Granada (4 males, 4 left-handed, mean age 20.5 years) participated in the experiment in exchange for course credits. They were all Spanish native speakers, had normal or corrected-to-normal vision and signed an informed consent form approved by the local Ethics Committee.

2.1.2. Apparatus and stimuli

A total of 300 Spanish words were used as targets (all of them were nouns; mean number of letters 5.5; range 2–8; mean frequency 49, range 1–184). Half of them referred to natural elements (e.g. mountain), whereas the other half designated man-made items (e.g. chair). Half of the words in each category had one of their letters altered, that is, they were noticeably bigger or smaller than the others, while the other words were perceptually unaltered. A white triangle in two different orientations (upwards or downwards) was used as cue. Additionally, a square composed of irregular black and white bars was used as mask. All stimuli were presented in a silver-gray background. The presentation of stimuli was developed and controlled using E-Prime experimental software, 2.0.10 version (Schneider, Eschman, & Zuccolotto, 2002) and run on a 17″ LG FLATRON L1718s screen with a 60 Hz refresh rate. The room was illuminated using a single 25 W light bulb. The luminance of the room was measured using a photometer and set at 5.2 candelas per square meter (cd/m^2).

2.1.3. Procedure

Each of the 300 words could be analyzed in two dimensions, namely a semantic and a perceptual one. At the semantic level, participants had to distinguish between words referring to either natural or man-made elements; at the perceptual level they had to report whether or not the target word contained an altered letter (i.e. larger or smaller than the others). Thus, in each trial participants had to perform one of the two tasks with the same set of targets. Each target was preceded by a cue that indicated the specific task to perform. Participants responded by pressing the Z, X, N or M keys (one for each possible response) on the keyboard. The index fingers of each hand (X and N keys) were used for one task and the middle fingers of each hand (Z and M keys) were used for the other task. The assignment of the orientation of the triangle and keys to tasks and responses was fully counterbalanced. Therefore, both the hand and the finger associated to a given response changed across participants. Cues were preceded and followed by masks. The proximity between cue and masks was set at three different fixation intervals, which modulated the degree of visibility of the cue. The fixation cross was presented during these intervals to help focus the attention of participants to the cue location. These intervals were adjusted approximations to the screen refresh rate (16.73 ms). The OU, SU and conscious awareness (CA) conditions, respectively, had intervals of one (16.73 ms), three (47.1 ms) and six (100.6 ms) refresh rates between masks and cue. Additionally, the interval between the post-cue mask and the target (mask-target interval; MTI) was either short (17 ms) or long (1000 ms). This was included to explore whether having more or less time to get prepared influenced the potential non-conscious bias (Altmann, 2004; Meiran, 2000; Meiran, Chorev, & Sapir, 2000; Meiran, Hommel, Bibi, & Lev, 2002).

The main task consisted of 300 trials, presented randomly. Before the main task, participants performed a few practice trials. In every trial, after a 100 ms fixation point (0.7°), a 30 ms cue (upward or downward triangle; 4° × 4°) was preceded and followed by two masks (4° × 4°) of 200 ms of duration each. After the MTI, the target word (mean 3.8°) was presented for 200 ms. After the presentation of the target, participants responded during a 2500 ms fixation point (see Fig. 1).

Participants were asked to focus on the cues and respond in accordance with them even if they were not completely sure about which cue had appeared. Furthermore, they were told that no cues would be presented in some trials and that, in such cases, they should freely choose which task to perform. Cues were actually presented in all trials, although their visibility (and therefore, participants' awareness) varied according to the cue-mask interval.

To maintain similarity with previous studies (e.g. Reuss et al., 2011) to a maximum, thresholds of consciousness were not measured initially for each participant. Although doing so would have been desirable, estimating the thresholds in advance would have arisen suspicions in participants regarding the presence of cues in every trial. This could have undermined the instructions in the main task of choosing freely when "no cue was presented". Hence, thresholds were determined based on duration details obtained in previous studies (e.g. Reuss et al., 2011; Ruz et al., 2003) and pilot experiments performed using the current task. Such results suggested that the variability of thresholds among participants was small, so we used the values that were optimal for the OU and SU thresholds. Nonetheless, thresholds were checked individually after the main task. In the next sections, we will describe how we assessed OU and SU.

2.1.4. OU and SU measurement

In order to obtain an *objective* index of unawareness, participants had to perform forced-choice discriminations between the upward and downward triangles. One hundred and fifty trials were run with the same experimental structure of events in the main task. Participants were instructed to ignore the words and focus on the orientation of the triangle. They had to press either the Q or P keys to report whether the triangle pointed up or down (key assignments were counterbalanced across participants).

Afterwards, we queried participants about their *subjective* perception of the cue at every threshold of visibility. Although there has been a long debate about which subjective technique captures participants' experience better, empirical data support the use of graduated scales, such as the Perceptual Awareness Scale (PAS; Ramsøy & Overgaard, 2004). Specifically, the PAS has been considered "the most exhaustive" index for SU among a number of different measures (see Sandberg et al., 2010). We thus ran a short block of eighteen trials arranged as in the main task and presented a Likert-type scale that was similar to the PAS at the end of each one. Participants had to choose the number that better described their subjective cue perception on a scale ranging from 1 – labeled as "no subjective perception of the cue" – to 9 – labeled as "total awareness of the presence of the cue". These labels were used following the original PAS (Ramsøy & Overgaard, 2004). We increased the size of the scale from the original version (range 1–4) to give participants a larger number of alternatives and consequently reduce the occurrence of false negatives and positives (i.e. partially conscious states tagged as non-conscious and vice versa).

2.1.5. Design

The experiment had a within-participants design both for the main and the threshold assessment tasks. In the main task, we introduced the factors Task (perceptual vs. semantic), Visibility (OU, SU and CA), MTI (short vs. long) and Switch (same vs. different cue from the previous trial). We introduced the switch factor in accordance with previous studies (Reuss et al., 2011) that suggested the potential key role of cue repetition in this type of paradigms.

2.2. Results

Two of the participants were excluded from the analyses due to high error rates (over 30% of the trials).

2.2.1. Decision-making analysis

Following previous studies (Reuss et al., 2011; Schlaghecken & Eimer, 2004), we transformed participants' responses into an index reporting the percentage of times they had performed the cued task under each condition. Next, we introduced these data into a repeated-measures ANOVA. We applied the Greenhouse-Geisser correction to correct for sphericity violations when needed.

2.2.1.1. Cue biases at different thresholds of consciousness. The ANOVA yielded a main effect of Visibility, $F(2, 20) = 335.62$, $p < .001$, $\eta_p^2 = .97$, showing a significant increase in cue-congruent responses at SU ($M = 90.4$; $SD = 1.7$) compared to OU ($M = 51.8$; $SD = 1$), and at CA ($M = 95$; $SD = 1.1$) compared to SU. Both SU, $t(21) = 23.86$, $p < .001$, and CA scores, $t(21) = 41.34$, $p < .001$, differed from chance, whereas the OU score approached significant levels, $t(21) = 1.8$, $p < .09$. Crucially, the Switch factor modulated this main OU effect, $F(2, 20) = 3.58$, $p < .05$, $\eta_p^2 = .26$. At OU, the score was higher in cue-repetition trials ($M = 56.1$; $SD = 1.9$) than in no-repetition trials ($M = 47.4$; $SD = 1.7$), $F(1, 21) = 8.26$, $p < .01$, $\eta_p^2 = .28$. Whereas the former significantly differed from chance, $t(21) = 3.2$, $p < .005$, no differences were found in no-repetition situations, $t = -1.52$, $p = .14$.

2.2.1.2. Mask-target interval and Switch effects. The ANOVA yielded a main effect of MTI, $F(1, 21) = 7.17$, $p < .02$, $\eta_p^2 = .25$, since participants performed the cued task more often in the short ($M = 80.3$; $SD = .9$) than in the long ($M = 77.7$; $SD = 1$) MTI. There was also a main effect of Switch, $F(1, 21) = 7.22$, $p < .02$, $\eta_p^2 = .26$, as participants followed the cue to a greater extent when it was not repeated ($M = 80.9$; $SD = 1$) than when it was repeated ($M = 77.7$; $SD = 1.1$). These two factors interacted, $F(1, 21) = 6.45$, $p < .02$, $\eta_p^2 = .24$, revealing that whereas there were differences between no repetition ($M = 77$; $SD = 1.5$) and cue-repetition trials ($M = 83.6$; $SD = 1$) in the short MTI, $F(1, 21) = 13.82$, $p < .002$, $\eta_p^2 = .4$, these differences disappeared in long MTI trials, $F > 1$. However, neither the MTI × Visibility interaction, $F = 3.36$, $p > .05$, nor the MTI × Switch × Visibility interaction, $F = 1$, $p > .3$, were significant.

2.2.2. Objective index analysis

Participants' responses in the forced discrimination procedure were classified as hits, misses, false alarms and correct rejections. These data were transformed into a d' index. As expected, a single-sample t-test revealed that d' differed from zero both at CA ($M = 4.5$; $SD = .3$), $t(21) = 16.7$, $p < .001$, and at SU ($M = 4.2$; $SD = .69$), $t(21) = 28.48$, $p < .001$. By contrast, the d' at OU did not differ from zero ($M = .16$; $SD = .48$), $t(21) = 1.5$, $p > .13$, suggesting that participants' ability to detect specific OU stimuli was at chance levels.

To ascertain that the biases found in choices after non-conscious cues were not generated by changes in cue awareness, we assessed whether d' was modulated by the Switch factor, which was not the case ($F < 1$).

2.2.3. Subjective index analysis

To analyze subjective reports, we obtained an average Likert score for each threshold of consciousness and participant. A repeated measures ANOVA yielded a main effect of Visibility, $F(2, 20) = 161.62$, $p < .001$, $\eta_p^2 = .94$. The OU score ($M = 1.68$, $SD = 1.3$) differed from the SU score ($M = 6.69$, $SD = 2.15$), $F(1, 21) = 124.9$, $p < .001$, $\eta_p^2 = .86$, and from the CA score ($M = 7.9$, $SD = 1.34$), $F(1, 21) = 313.84$, $p < .001$, $\eta_p^2 = .94$. The SU score also differed from the CA score, $F(1, 21) = 20.6$, $p < .001$, $\eta_p^2 = .46$. Despite this significant difference, the SU score was higher than expected (Ramsøy & Overgaard, 2004; Sandberg et al., 2011). This issue will be discussed in the next section.

2.3. Discussion

Our results support the idea that decisions made by participants can be biased by symbolic information that is not perceived consciously. In the OU condition, participants chose to perform the task signaled by the non-conscious cue to a larger extent, but only when it matched the cue in the previous trial. Surprisingly, cues presented at SU generated similar effects to conscious ones, that is, participants followed the cue instructions in a large percentage of trials. Unfortunately, participants' subjective reports in this SU condition were unexpectedly high. Although they were statistically different from reports for cues presented consciously, such high scores limit the scope of the inferences that can be made regarding SU results. Hence, in the following studies of this series we reduced the cue-mask intervals to obtain a more accurate SU.

Overall, results from Experiment 1 provide suggestive evidence of non-conscious activation of task sets, in agreement with previous studies (Kiesel et al., 2006; Reuss et al., 2011; Schlaghecken & Eimer, 2004; Weibel, Giersch, Dehaene, & Huron, 2013). However, an alternative explanation could be that participants in OU trials displayed a tendency to repeat the previous decision, which may have led to the effects that we observed only in non-switch trials. To obtain evidence against this explanation and to explore the dependence of the effect on the conscious mental state, we performed Experiment 2. As mentioned in the introduction, recent theoretical and experimental approaches in the field propose that non-conscious biases depend on conscious intentions and expectations (Kiefer & Martens, 2010; Kunde, Kiesel, & Hoffmann, 2003; Naccache et al., 2002; Schlaghecken & Eimer, 2004), although it is not yet known whether these influences apply to free decisions. In Experiment 2, we presented cues of different visibility in separate blocks and thus manipulated participants' expectations by making cue visibility predictable. Hence, participants knew in advance whether they would perceive the cue in the next trial. As in Experiment 1, participants were instructed to freely choose the task to perform when "no cue was present" (i.e. non-conscious cued trials). In line with current theories (Kiefer & Martens, 2010), we hypothesized that the prediction of an incoming non-conscious trial would eliminate the non-conscious influence of cues as participants would no longer seek for this information in blocks in which they expected that no cue would be presented. By contrast, if the bias observed in Experiment 1 was the result of a tendency to repeat the previous decision and unrelated to non-conscious processing, we should obtain the same effect in Experiment 2.

3. Experiment 2

3.1. Method

3.1.1. Participants

Twenty-four students of the University of Granada (1 men, 2 left-handed, mean age 22 years) participated in the experiment in exchange for course credits. They all were Spanish native speakers, had normal or corrected-to-normal vision, and signed an informed consent form approved by the local Ethics Committee.

3.1.2. Apparatus and stimuli

The same stimuli as in Experiment 1 were used. The experiment was conducted using the same version of E-Prime, running on the same computers and under the same lighting conditions.

3.1.3. Procedure

The experiment structure was very similar to Experiment 1, with the major difference that we presented trials of different visibility in blocks rather than in random order. The sequence of blocks was counterbalanced across participants. As in Experiment 1, participants performed a few practice trials after the instructions. During these practice trials, they learned to choose between the two tasks when they had no awareness of the presence of the cue (OU and SU blocks). Additionally, based on the results from Experiment 1, we reduced the cue-mask intervals in the SU condition from 3 to 2 refresh rates (33.46 ms) to obtain a more accurate SU. The use of blocks and the new SU interval were also applied to the threshold-checking procedures. The remaining details did not change from Experiment 1.

3.2. Results

One participant was excluded from the analyses due to an excessive error rate (over 30% of the trials).

3.2.1. Decision-making analysis

3.2.1.1. Cue biases at different thresholds of consciousness. We found an effect of Visibility, $F(2, 21) = 160.7$, $p < .001$, $\eta_p^2 = .94$. As expected, the percentage of trials in which participants followed the cue was larger at CA ($M = 95$; $SD = 1.3$) than at SU ($M = 62$; $SD = 3.7$), and was higher at SU than at OU ($M = 52$; $SD = 2$). The first two scores significantly differed from chance, $t(22) = 33.85$, $p < .001$, and $t(22) = 3.23$, $p < .005$, at CA and SU, respectively. However, the OU score was not different from chance, $t < 1$. Unlike the results of Experiment 1, these scores were not modulated by the Switch factor, $F(1, 22) = 1.26$, $p > .3$ (see Fig. 2). Additionally, we performed a new ANOVA to check whether the order of presentation of blocks affected these results. The main effect of block and its interaction with the Visibility factor were not significant (all Fs < 1).

3.2.1.2. Switch effects. The ANOVA also revealed a main effect of Switch, $F(1, 22) = 6.28$, $p < .03$, $\eta_p^2 = .22$, since participants performed the cued task more in non-switch ($M = 70.3$; $SD = 1.7$) than in switch trials ($M = 68.6$; $SD = 1.7$). An additional ANOVA ruled out an interaction between Switch and block order ($F < 1$).

3.2.2. Objective index analysis

The analysis of objective scores showed that the d' was significantly different from 0 in both the SU ($M = 2.2$; $SD = 1.7$), $t(22) = 50.1$, $p < .001$, and the CA ($M = 4.5$; $SD = .4$) conditions, $t(22) = 16.3$, $p < .001$, but not in the OU condition ($M = .3$; $SD = .9$), $t(22) = 1.7$, $p > .05$.

3.2.3. Subjective index analysis

We found a main effect of Visibility in the Likert scores, $F(2, 21) = 180.1$, $p < .001$, $\eta_p^2 = .95$. OU scores ($M = 2.2$; $SD = .3$) differed from SU scores ($M = 3.8$; $SD = .4$), $F(1, 22) = 31.18$, $p < .001$, $\eta_p^2 = .59$, and CA scores ($M = 8.3$; $SD = .2$), $F(1, 22) = 365.53$, $p < .001$, $\eta_p^2 = .94$. Again, SU scores also differed from CA scores, $F(1, 22) = 129.38$, $p < .001$, $\eta_p^2 = .86$. In contrast with Experiment 1, the SU score (3.8 out of 9) resembled the scores related to the experience of a "brief glimpse" (2 out of 4) obtained in the Perceptual Awareness Scale (Ramsøy & Overgaard, 2004; Sandberg et al., 2011). According to Ramsøy and Overgaard (2004), this score reflects "the feeling that something has been shown [...], not characterized by any content"; a feeling that "cannot be specified any further".

3.3. Discussion

As predicted, when participants believed there was no information to be searched regarding what to do next, the effect of non-conscious information presented at OU disappeared. To put it another way, our results suggest that conscious expectations about the presence of useful information for task guidance funnel the effect of non-conscious information. In addition, the current results provide support against an explanation of the non-conscious bias observed in Experiment 1 in terms of a tendency to repeat the choice made in the previous trial. The tendency to perform the cued task more frequently in non-switch than in switch trials was present in the current experiment, as evidenced by the significant main effect of Switch on decisions. Arguably, if such strategy drove the effects observed in Experiment 1, the allegedly non-conscious bias should also be present in the current experiment. This, however, was not the case.

An alternative explanation could be that cue instructions and not choice/response repetition may have generated the OU bias in non-switch trials observed in Experiment 1. In fact, the effect could be explained by a mere repetition of previously seen instructions. Since in Experiment 2 the cue was invisible throughout the whole OU block, participants were not able to repeat the instruction and consequently the effect vanished. To rule out this possibility, we performed an additional analysis of Experiment 1 including visibility in the previous trial (CA, SU, OU) as an additional factor. Results showed that this factor did not modulate the effect of the cue in the OU condition in Experiment 1, ($F = 1.1$, $p = .35$), which indicates that instruction repetition did not account for the effects we found in Experiment 1 or 2.

In addition, the SU estimation was more accurate in Experiment 2, as subjective reports were now consistent with the lack of subjective perception of the cues. In fact, the score obtained has been previously related to a low subjective experience of form (Ramsøy & Overgaard, 2004) but a high detection accuracy (Sandberg et al., 2011) in equivalent scores on the Perceptual Awareness Scale. Interestingly, the effect of SU cues was still highly significant. One could say these results are due to some degree of residual consciousness that escapes subjective reports (Block, 2007), but it is also possible that the lower degree of perceptual degradation of cues at SU helps boost their non-conscious effect in the system (Merikle et al., 2001; Snodgrass & Shevrin, 2006). We will return to this issue in the General Discussion.

Still, there was an additional alternative explanation to our results. The difference between Experiments 1 and 2 could be due to the use of an intermixed vs. blocked order rather than to the predictability of the sequence. Thus, the effect may have disappeared as a mere consequence of blocking the non-conscious trials in Experiment 2. To rule out this alternative explanation, we performed a new experiment in which we compared a random sequence with a predictable sequence of intermixed OU, SU and CA trials. By allowing this prediction to take place, we expected to eliminate the bias in OU trials again. It should be noted that this trial-by-trial sequence is stricter than a blocked one, since in the former the strategy of whether or not paying attention to the cue period has to be applied in each trial. Conversely, in a blocked setting such as that of Experiment 2, the strategy can be applied during the whole block period. Thus, Experiment 3 had two major goals: using alternating trials both in the predictable and unpredictable conditions, and replicating the results of Experiment 1 and 2 with a new sample of participants.

4. Experiment 3

4.1. Method

4.1.1. Participants

Forty-eight students (24 in each group, equivalent to the previous two experiments) of the University of Granada (7 males, 4 left-handed, mean age 20.3 years) participated in the study after signing an informed consent form approved by the local Ethics Committee and received course credits in exchange. They all were Spanish native speakers and had normal or corrected-to-normal vision.

4.1.2. Apparatus and stimuli

We used the same apparatus and stimuli as in Experiments 1 and 2.

4.1.3. Procedure

We introduced a between-participants manipulation of the predictability of the sequence of trials. Half of the participants performed a replication of Experiment 1 (with an adjusted SU as described in Experiment 2) in which the appearance of cues at different thresholds was randomized; the other half performed the task in a predictable sequence of cue visibility, which was set in advance. Trials with different thresholds of consciousness followed each other in a repetitive fashion (i.e. SU–OU–CA or OU–SU–CA; the two different sequences were counterbalanced across participants). All the within-participants factors remained the same as in previous experiments. These manipulations were used in the threshold-checking procedures as well.

4.2. Results

Three participants were excluded from the analyses due to an excessive error rate (over 30% of trials).

4.2.1. Decision-making analysis

4.2.1.1. Cue biases at different thresholds of consciousness. The analysis revealed a main effect of Visibility, $F(2, 42) = 227.26$, $p < .001$, $\eta_p^2 = .92$. As in Experiments 1 and 2, the effect of the cue increased along with its visibility (OU, $M = 52.9$, $SD = 1.1$; SU, $M = 67.8$, $SD = 2.6$; CA, $M = 93$, $SD = 1.5$). The three scores were significantly different from chance, $t(46) = 2.72$, $p < .01$, $t(46) = 7.62$, $p < .001$, and $t(46) = 30.94$, $p < .001$, in the OU, SU and CA conditions, respectively.

Importantly, OU scores differed between groups, $F(1, 43) = 5.08$, $p < .03$, $\eta_p^2 = .11$. While the OU score in the predictable group ($M = 50.3$; $SD = 5.3$) was equal to chance, $t < 1$, it was significant higher than chance in the random group ($M = 55.5$; $SD = 9.3$), $t(22) = 2.81$, $p < .015$. No differences were found between switch and non-switch trials in OU trials in either the predictable, $F < 1$, or the random group, $F = 1.80$, $p = .19$ (see Fig. 3). Along with the results from Experiment 2, this argues against a conscious repetition strategy as the explanation for the OU biases we found.

In SU trials, the Group factor modulated the switch effect, since switch ($M = 63.2$; $SD = 3.7$) and non-switch ($M = 68.2$; $SD = 3.9$) scores were different in the Predictable sequence group, $F(1, 43) = 6.01$, $p < .02$, $\eta_p^2 = .12$, but statistically equal in the Random sequence group, $F = 1.45$, $p = .24$. However, participants' decisions differed from chance level in all cases, namely switch trials, $t(21) = 3.\ 33$, $p < .004$, and non-switch trials, $t(21) = 4.95$, $p < .001$, in the Predictable sequence group, and switch trials, $t(22) = 6.2$, $p < .001$, and non-switch trials, $t(22) = 4.7$, $p < .001$, in the Random sequence group.

4.2.1.2. Mask-target interval and Switch effects. The ANOVA also yielded a Switch × MTI interaction, $F(1, 43) = 6.02$, $p < .02$, $\eta_p^2 = .12$. As in Experiment 1, the difference between switch ($M = 68.8$; $SD = 1.5$) and non-switch trials ($M = 73.2$; $SD = 1.5$) was only found in Short MTI trials, $F(1, 43) = 7.6$, $p < .002$, $\eta_p^2 = .15$. No differences were found in Long MTI situations, $F < 1$. Neither the MTI × Visibility interaction, $F < 1$, nor the Switch × MTI × Visibility interaction, $F = 1.91$, $p = .14$, were significant, suggesting that the effect of the cue in subliminal thresholds did not change across different MTI or switch situations.

4.2.2. Objective index analysis

Regarding the objective index, d' scores differed from zero both at SU ($M = 2.01$; $SD = 1.52$), $t(44) = 8.84$, $p < .001$, and CA ($M = 4.33$; $SD = .90$), $t(44) = 32.33$, $p < .001$. As expected, they did not differ from zero at OU ($M = .17$; $SD = .1$), $t = 1.84$, $p > .26$. Crucially, these results were not mediated by the Switch or the Group factors, all *F*s < 1.

4.2.3. Subjective index analysis

There was a main effect of Visibility as measured by the Likert scale, $F(2, 45) = 514.12$, $p < .001$, $\eta_p^2 = .96$. Likert scores at OU ($M = 2.07$; $SD = .18$) were lower than at SU ($M = 4.36$; $SD = .36$) and at CA ($M = 8.6$; $SD = .13$). Neither the main effect of Group nor its interaction with the Visibility of the cue were significant, all *F*s < 1. SU scores matched those obtained with the Perceptual Awareness Scale using similar time intervals (Ramsøy & Overgaard, 2004; Sandberg et al., 2011).

4.3. Discussion

The expectations about the presence or not of information useful to guide our behavior are a crucial modulator of the bias that non-conscious information exerts in simple dichotomous decisions. Our results show that cues presented at OU biased participants' choices, but only when the unpredictability of the sequence set them to search for cue information in every trial. By contrast, when the sequence of events led them not to expect cues in certain trials, their effect at OU vanished. This suggests that non-conscious OU bias in decision-making is a true phenomenon but that it depends on an appropriate conscious mindset to take place (Kiefer & Martens, 2010).

Additionally, although the cue effect was larger in short MTI trials, it did not significantly change in long MTI ones, where no differences were found between switch and non-switch trials. Since under this MTI the preparation for switch and non-switch trials is thought to be mainly equated (Altmann, 2004; Meiran, 2000; Meiran et al., 2000, 2002), the reduction of switching costs alone cannot explain the increase of a non-conscious priming effect in cue repetition trials. Instead, other processes such as accumulation of information (De Lange, van Gaal, Lamme, & Dehaene, 2011; Van Gaal, Lamme, & Ridderinkhof, 2010) may also play a role in the benefits of non-switching trials. These benefits may partially account for the non-conscious bias we found in OU conditions, rather than a simple conscious strategy to repeat the $n - 1$ task.

Moreover, the non-conscious cues presented in the SU generated a significant bias that did not interact with the predictability of the sequence as it took place in both groups to the same extent. Thus, unlike OU results, SU effects were not sensitive to the manipulation of conscious expectations. This is in line with the existence of differences in behavioral outcomes of information presented at both thresholds of consciousness (Merikle et al., 2001; Snodgrass & Shevrin, 2006), which we will discuss in the next section.

5. General discussion

The aim of the present study was to assess the influence of non-conscious information on decision making as well as the extent to which the conscious mindset modulates this influence. Results from Experiment 1 suggest that task sets can be activated outside awareness to modulate subsequent choices. Experiments 2 and 3 demonstrate that OU subliminal biases in decision making depend on conscious expectations and that the results of the previous experiment could not be fully accounted by a tendency to repeat either the previous response or the previous instruction. Additionally, we provide suggestive evidence that different states of unawareness lead to different outcomes, a result that should be taken into account in future studies.

Our data show that task-set selection is not immune to the influence of non-conscious information. Our design presented cues at different levels of visibility and random order and demonstrated that non-conscious cues can prime choices without the need of previous conscious instructions. Decision-making data, which were replicated in two separate experiments (1 and 3), point in this direction. Importantly, these results took place under very strict conditions of visibility, since d' was equal to zero, and this index was never modulated by the factors that had an impact on the non-conscious bias in the OU condition, such as sequential effects in Experiment 1 and the predictability of the sequence of trials in Experiment 3. This set of findings suggests that residual visibility was not an explanation of the biasing effects found in choices.

Another relevant and novel manipulation was the use of short and long preparation intervals (MTI). Our results showed a non-conscious bias effect when the time between the mask and the target was short, suggesting the automatic nature of the processes elicited by our paradigm. However, the effect of the cue in objective unawareness states was not significantly modulated by the MTI factor, indicating that the non-conscious bias also took place even when more controlled processing was applied.

As mentioned earlier, an initial alternative explanation could have been that participants were aware of the task they had just performed and subsequently tended to repeat it in the following trial. In Experiment 1, for instance, the cue effect in OU trials only took place in the cue repetition condition. However, even though this meta-awareness may have played a role, it cannot account on its own for the set of observed effects. First, the non-conscious bias disappeared when participants did not expect the appearance of relevant cue information, even when a general tendency to repeat the previous response was present (as evidenced by a main effect of Switch on decisions in both Experiments 2 and 3). In addition, data from Experiment 3 revealed an OU non-conscious effect also in switch trials, supporting the idea that a conscious strategy to repeat the $n-1$ decision cannot account for the non-conscious results. Awareness state measurements obtained in the three experiments point in the same direction, as the d' index was never affected by the switch factor. If participants had the tendency to repeat the previous decisions when they did not see the cue, this should have also been observed during awareness estimation, which was not the case. Additionally, one may think that this conscious strategy should have also affected SU trials, since participants were subjectively unaware of the cue as well. However, although the cue effect was greater in cue-repetition SU trials, it was higher than chance level in all cases. Altogether, these facts provide compelling evidence that conscious task repetition is not the main explanation for our results. Moreover, additional analyses suggest that a strategy to merely repeat an instruction that has been previously seen does not stand either. Nevertheless, our study was not primarily focused on the cue repetition effect so the specific role that it plays on the unconscious selection of task sets should be explored in future studies with optimized designs aimed at measuring this.

Experiments 2 and 3 showed that the OU non-conscious effects were highly dependent on conscious expectations. In Experiment 2, the predictability of cue visibility granted by blocking trials eliminated the priming effect. In non-conscious OU blocks, participants were not biased by the cue because they did not expect any useful information to be presented during the cue period. This is likely to have driven participants to stop searching for information during the cue period. In the same vein, Experiment 3 showed that this effect did not depend on the block manipulation, as it also appeared when non-conscious trials were mixed with conscious ones in a predictable sequence.

Our results are consistent with several current models of automaticity that argue that top-down conscious processes funnel non-conscious cognition and crucially extend this approach to the decision-making field in a novel way. The fundamental premise of these models is that non-conscious effects occur insofar congruent goals are set in a conscious background (Kiefer & Martens, 2010). Thus, top-down mechanisms enhance task-relevant processes while attenuating task-irrelevant information. In consequence, subliminal information is ineffective without the appropriate conscious preparation (Dehaene & Naccache, 2001). Although this prediction has been confirmed with various processes, our data are the first to provide a reliable extension of this prediction to decision-making situations (Kiefer et al., 2012). In addition, our results are also consistent with models that propose a hierarchy of control processes (Koechlin, Ody, & Kouneiher, 2003). Koechlin et al. (2003) established three levels: a first, lower level is based on premotor representations of sensory control, in which motor actions are linked to specific responses to stimuli. A second, intermediate level selects representations of the first level, based on demands of the context (i.e. task sets containing stimulus–response associations). Finally, a higher episodic control selects these contextual task sets "according to ongoing internal goals". We propose that non-conscious information exerts its influence on decision-making at the intermediate contextual level, boosting the activation of specific task sets. However, this non-conscious influence relies on higher episodic control processes, which are based on conscious expectations. In further studies, it would be crucial to test if non-conscious information can also affect these higher episodic control processes in decision-making (Newell & Shanks, 2014).

Another important finding is that the manipulation of expectations did not have an effect under SU. Moreover, the non-conscious bias was much stronger at the SU threshold than at the OU threshold. These two facts suggest that both thresholds are "indexing different phenomena" (Snodgrass & Shevrin, 2006). A conservative interpretation of this difference would claim that SU is essentially conscious, since subjective reports could be misleading (Block, 2007; Hannula, Simons, & Cohen, 2005; Holender & Duscherer, 2004). Thus, results in the SU condition are likely to be the consequence of a weaker conscious perception of which participants are not fully aware. However, an alternative explanation could be that information presented in OU conditions is extremely degraded (e.g. Lau & Rosenthal, 2011). The small effects found in this state may be due to perceptual representations of stimuli that greatly differ from normal perceptual representations. Subsequently, it would not be fair to compare OU with CA since their perceptual features are not fully equated (Merikle et al., 2001). In fact, SU effects may reflect a more accurate perceptual representation of stimuli, which would boost the non-conscious effect. The differentiation between phenomenal and reflective representations may help to shed some light on this issue. As it has been proposed previously (Snodgrass & Shevrin, 2006; Snodgrass et al., 2004), under OU conditions, both (phenomenal and reflective) representations of the stimulus are unconscious. In SU stimuli, by contrast, the phenomenal representation is likely to be conscious but the higher-order reflective process about this percept is likely to remain unconscious. This framework would explain the existence of the large cue effect in SU conditions (strong phenomenal representation) in the absence of subjective experience (in accordance with previous subjective scales results). Thus, it seems that these higher-level strategies (i.e. expectations) have a remarkable effect on OU trials but are apparently ineffective in reflective representations (SU trials). Again, this intact phenomenal representation would explain the lack of modulation of the SU effect in our experiments.

In sum, our results suggest that an adequate deployment of attentional resources is essential when the phenomenal features of stimuli are degraded to a poor representation (i.e. OU). In fact, it is widely assumed that under these circumstances, some non-conscious effects do not occur without attention (Dehaene, Changeux, Naccache, Sackur, & Sergent, 2006; Koch &

Tsuchiya, 2007). However, it has been reported that in less restrictive situations, priming effects of cognitive control processes can take place without attention (Rahnev, Huang, & Lau, 2012). This is consistent with some computational models that propose two differentiated forms of top-down attention, one for phenomenal representations and another one for higher-order reflective percepts (Raffone & Pantani, 2010). Likewise, in SU trials, the phenomenal representation of stimuli appears to be good enough not to depend on an adequate mobilization of phenomenal top-down attention. Hence, the influence of conscious expectations is likely to be weaker. Our results point to the existence of interesting evidence of subjectively unawareness states, which are currently being partially neglected in non-conscious priming literature. Future studies should take into account both subjective and objective thresholds of consciousness and assess whether this pattern of results is replicable in well-established classic paradigms.

6. Conclusions

Our study reveals several aspects of non-conscious decision-making. First, non-conscious information is able to bias a simple task choice. This bias takes place even under very restrictive conditions of visibility. Different confounds were ruled out, suggesting the non-conscious nature of the effect. Second, the bias is larger in a subjective unawareness state, probably due to a better phenomenal representation of the cue stimuli. This result endorses the use of less restrictive measures of awareness than those used to establish objective thresholds. Additionally, our results show that these two states are qualitatively different, since conscious expectations have a different weight in each condition. Whereas ongoing goals did not modulate the effect of non-conscious information at SU, they clearly had an effect at OU. Indeed, we found that goals only had an influence on task selection when they were adjusted to the features of non-conscious stimuli. This evidence altogether argues against the classical interpretation of task-set selection processes in which the given outputs of the process depend only on conscious features. Instead, our results show that the influence of non-conscious information on our choices and the different conditions that enable this should be taken into account in future studies on the field.

Acknowledgments

The Spanish Ministry of Science and Innovation provided financial support for this research through a 'Ramón y Cajal' research fellowship (RYC-2008-03008) and grants PSI2010-16421 and PSI2013-45567-P to M.R. The Regional Government of Andalusia provided funding for P.T. through grant P09.HUM.5422. This research is part of C.G-G's activities for the Psychology Graduate Program of the University of Granada.

Appendix A

See Fig. 1.

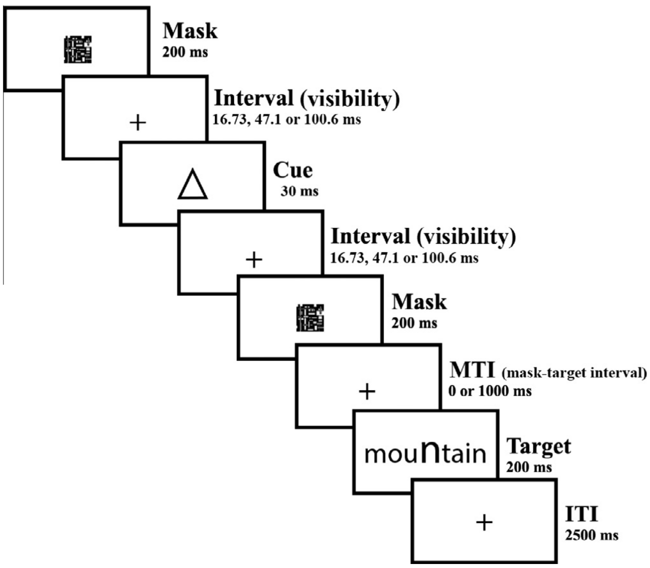

Fig. 1. Experimental procedure in phases 1 and 2 across the three experiments. Mask-cue intervals for the OU, SU and CA conditions were equivalent to 1, 3 and 6 screen refresh rates (16.73, 47.1 and 100.6 ms, respectively).

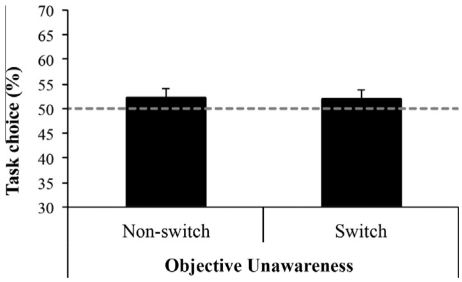

Fig. 2. Percentage of congruent responses at OU for both cue-repetition and no-repetition trials (± S.E.M.) in Experiment 2. The dashed line represents chance levels (50%).

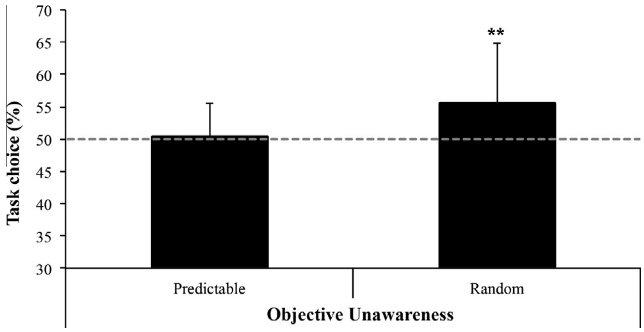

Fig. 3. Percentage of congruent responses at OU in both groups of participants (± S.E.M.) in Experiment 3.The dashed line represents chance level (50%). Stars represent statistical differences from chance ($p < .015$).

Appendix B

See Fig. 2.

Appendix C

See Fig. 3.

References

Altmann, E. M. (2004). The preparation effect in task switching: Carryover of SOA. *Memory & Cognition, 32*(1), 153–163. http://dx.doi.org/10.3758/BF03195828.

Ansorge, U., & Horstmann, G. (2007). Preemptive control of attentional capture by colour: Evidence from trial-by-trial analyses and orderings of onsets of capture effects in reaction time distributions. *The Quarterly Journal of Experimental Psychology, 60*(7), 952–975.

Ansorge, U., Horstmann, G., & Scharlau, I. (2010). Top–down contingent attentional capture during feed-forward visual processing. *Acta Psychologica, 135*(2), 123–126.

Ansorge, U., Horstmann, G., & Scharlau, I. (2011). Top-down contingent feature-specific orienting with and without awareness of the visual input. *Advances in Cognitive Psychology, 7*(1), 108–119.

Ansorge, U., Kunde, W., & Kiefer, M. (2014). Unconscious vision and executive control: How unconscious processing and conscious action control interact. *Consciousness and cognition, 27*, 268–287.

Armstrong, A. M., & Dienes, Z. (2013). Subliminal understanding of negation: Unconscious control by subliminal processing of word pairs. *Consciousness and Cognition, 22*(3), 1022–1040.

Block, N. (2007). Consciousness, accessibility, and the mesh between psychology and neuroscience. *The Behavioral and Brain Sciences, 30*(5–6), 481–499. http://dx.doi.org/10.1017/S0140525X07002786. discussion 499–548.

Chalmers, D. J. (1996). *The conscious mind: In search of a fundamental theory*. Oxford University Press.

Chiu, Y.-C., & Aron, A. R. (2014). Unconsciously triggered response inhibition requires an executive setting. *Journal of Experimental Psychology: General*. http://dx.doi.org/10.1037/a0031497.

De Lange, F. P., van Gaal, S., Lamme, V. A. F., & Dehaene, S. (2011). How awareness changes the relative weights of evidence during human decision-making. *PLoS Biology, 9*(11), e1001203. http://dx.doi.org/10.1371/journal.pbio.1001203.

Dehaene, S., & Changeux, J.-P. (2011). Experimental and theoretical approaches to conscious processing. *Neuron, 70*(2), 200–227. http://dx.doi.org/10.1016/j.neuron.2011.03.018.

Dehaene, S., Changeux, J.-P., Naccache, L., Sackur, J., & Sergent, C. (2006). Conscious, preconscious, and subliminal processing: A testable taxonomy. *Trends in Cognitive Sciences, 10*(5), 204–211. http://dx.doi.org/10.1016/j.tics.2006.03.007.

Dehaene, S., & Naccache, L. (2001). Towards a cognitive neuroscience of consciousness: Basic evidence and a workspace framework. *Cognition, 79*(1–2), 1–37. http://dx.doi.org/10.1016/S0010-0277(00)00123-2.

Dennett, D. C. (2003). Who's on first? Heterophenomenology explained. *Journal of Consciousness Studies, 10*(9), 19–30.

Dennett, D. C. (2007). Heterophenomenology reconsidered. *Phenomenology and the Cognitive Sciences, 6*(1–2), 247–270. http://dx.doi.org/10.1007/s11097-006-9044-9.

Haggard, P. (2008). Human volition: Towards a neuroscience of will. *Nature Reviews Neuroscience, 9*(12), 934–946. http://dx.doi.org/10.1038/nrn2497.

Hannula, D. E., Simons, D. J., & Cohen, N. J. (2005). Imaging implicit perception: Promise and pitfalls. *Nature Reviews Neuroscience, 6*(3), 247–255. http://dx.doi.org/10.1038/nrn1630.

Holender, D. (1986). Semantic activation without conscious identification in dichotic listening, parafoveal vision, and visual masking: A survey and appraisal. *Behavioral and Brain Sciences, 9*(01), 1–23. http://dx.doi.org/10.1017/S0140525X00021269.

Holender, D., & Duscherer, K. (2004). Unconscious perception: The need for a paradigm shift. *Perception & Psychophysics, 66*(5), 872–881. http://dx.doi.org/10.3758/BF03194980.

Hommel, B. (2007). Consciousness and control: Not identical twins. *Journal of Consciousness Studies, 14*(1–2), 155–176.

Kiefer, M. (2012). Executive control over unconscious cognition: Attentional sensitization of non-conscious information processing. *Frontiers in Human Neuroscience, 6*, 61. http://dx.doi.org/10.3389/fnhum.2012.00061.

Kiefer, M., Adams, S. C., & Zovko, M. (2012). Attentional sensitization of unconscious visual processing: Top-down influences on masked priming. *Advances in Cognitive Psychology, 8*(1), 50.

Kiefer, M., & Brendel, D. (2006). Attentional modulation of unconscious "automatic" processes: Evidence from event-related potentials in a masked priming paradigm. *Journal of Cognitive Neuroscience, 18*(2), 184–198.

Kiefer, M., & Martens, U. (2010). Attentional sensitization of unconscious cognition: Task sets modulate subsequent masked semantic priming. *Journal of Experimental Psychology: General, 139*(3), 464–489. http://dx.doi.org/10.1037/a0019561.

Kiesel, A., Wagener, A., Kunde, W., Hoffmann, J., Fallgatter, A. J., & Stöcker, C. (2006). Unconscious manipulation of free choice in humans. *Consciousness and Cognition, 15*(2), 397–408. http://dx.doi.org/10.1016/j.concog.2005.10.002.

Koch, C., & Tsuchiya, N. (2007). Attention and consciousness: Two distinct brain processes. *Trends in Cognitive Sciences, 11*(1), 16–22. http://dx.doi.org/10.1016/j.tics.2006.10.012.

Koechlin, E., Ody, C., & Kouneiher, F. (2003). The architecture of cognitive control in the human prefrontal cortex. *Science, 302*(5648), 1181–1185.

Kouider, S., & Dehaene, S. (2007). Levels of processing during non-conscious perception: A critical review of visual masking. *Philosophical Transactions of the Royal Society B: Biological Sciences, 362*(1481), 857–875. http://dx.doi.org/10.1098/rstb.2007.2093.

Kunde, W., Kiesel, A., & Hoffmann, J. (2003). Conscious control over the content of unconscious cognition. *Cognition, 88*(2), 223–242. http://dx.doi.org/10.1016/S0010-0277(03)00023-4.

Kunde, W., Reuss, H., & Kiesel, A. (2012). Consciousness and cognitive control. *Advances in Cognitive Psychology/University of Finance and Management in Warsaw, 8*(1), 9–18. http://dx.doi.org/10.2478/v10053-008-0097-x.

Lau, H. C., & Passingham, R. E. (2007). Unconscious activation of the cognitive control system in the human prefrontal cortex. *The Journal of Neuroscience, 27*(21), 5805–5811. http://dx.doi.org/10.1523/JNEUROSCI.4335-06.2007.

Lau, H. C., & Rosenthal, D. (2011). Empirical support for higher-order theories of conscious awareness. *Trends in Cognitive Sciences, 15*(8), 365–373. http://dx.doi.org/10.1016/j.tics.2011.05.009.

Logan, G. D., & Bundesen, C. (2004). Very clever homunculus: Compound stimulus strategies for the explicit task-cuing procedure. *Psychonomic Bulletin & Review, 11*, 832–840.

Marcel, A. J. (1983). Conscious and unconscious perception: Experiments on visual masking and word recognition. *Cognitive Psychology, 15*(2), 197–237. http://dx.doi.org/10.1016/0010-0285(83)90009-9.

Mattler, U. (2003). Priming of mental operations by masked stimuli. *Perception & Psychophysics, 65*(2), 167–187.

Mattler, U. (2005). Inhibition and decay of motor and nonmotor priming. *Perception & Psychophysics, 67*(2), 285–300.

Mattler, U. (2006). On the locus of priming and inverse priming effects. *Perception & Psychophysics, 68*(6), 975–991.

Mattler, U. (2007). Inverse target-and cue-priming effects of masked stimuli. *Journal of Experimental Psychology: Human Perception and Performance, 33*(1), 83.

Meiran, N. (2000). Modeling cognitive control in task-switching. *Psychological Research, 63*(3–4), 234–249. http://dx.doi.org/10.1007/s004269900004.

Meiran, N., Chorev, Z., & Sapir, A. (2000). Component processes in task switching. *Cognitive Psychology, 41*(3), 211–253. http://dx.doi.org/10.1006/cogp.2000.0736.

Meiran, N., Hommel, B., Bibi, U., & Lev, I. (2002). Consciousness and control in task switching. *Consciousness and Cognition, 11*(1), 10–33. http://dx.doi.org/10.1006/ccog.2001.0521.

Merikle, P. M., & Reingold, E. M. (1998). On demonstrating unconscious perception: Comment on Draine and Greenwald (1998). *Journal of Experimental Psychology. General, 127*(3), 304–310.

Merikle, P. M., Smilek, D., & Eastwood, J. D. (2001). Perception without awareness: Perspectives from cognitive psychology. *Cognition, 79*(1–2), 115–134. http://dx.doi.org/10.1016/S0010-0277(00)00126-8.

Naccache, L., Blandin, E., & Dehaene, S. (2002). Unconscious masked priming depends on temporal attention. *Psychological Science, 13*(5), 416–424. http://dx.doi.org/10.1111/1467-9280.00474.

Newell, B. R., & Shanks, D. R. (2014). Unconscious influences on decision making: A critical review. *Behavioral and Brain Sciences, 37*(01), 1–19. http://dx.doi.org/10.1017/S0140525X12003214.

Overgaard, M., Timmermans, B., Sandberg, K., & Cleeremans, A. (2010). Optimizing subjective measures of consciousness. *Consciousness and Cognition, 19*(2), 682–684.

Peirce, C. S., & Jastrow, J. (1884). On small differences in sensation. *Memoirs of the National Academy of Sciences, 3*, 75–83.

Raffone, A., & Pantani, M. (2010). A global workspace model for phenomenal and access consciousness. *Consciousness and Cognition, 19*(2), 580–596. http://dx.doi.org/10.1016/j.concog.2010.03.013.

Rahnev, D. A., Huang, E., & Lau, H. (2012). Subliminal stimuli in the near absence of attention influence top-down cognitive control. *Attention, Perception, & Psychophysics, 74*(3), 521–532. http://dx.doi.org/10.3758/s13414-011-0246-z.

Ramsøy, T. Z., & Overgaard, M. (2004). Introspection and subliminal perception. *Phenomenology and the Cognitive Sciences, 3*(1), 1–23.

Reuss, H., Kiesel, A., Kunde, W., & Hommel, B. (2011). Unconscious activation of task sets. *Consciousness and Cognition, 20*(3), 556–567. http://dx.doi.org/10.1016/j.concog.2011.02.014.

Rosenthal, D. M. (2008). Consciousness and its function. *Neuropsychologia, 46*(3), 829–840. http://dx.doi.org/10.1016/j.neuropsychologia.2007.11.012.

Ruz, M., Madrid, E., Lupiáñez, J., & Tudela, P. (2003). High density ERP indices of conscious and unconscious semantic priming. *Cognitive Brain Research, 17*(3), 719–731. http://dx.doi.org/10.1016/S0926-6410(03)00197-6.

Sandberg, K., Bibby, B. M., Timmermans, B., Cleeremans, A., & Overgaard, M. (2011). Measuring consciousness: Task accuracy and awareness as sigmoid functions of stimulus duration. *Consciousness and Cognition, 20*(4), 1659–1675.

Sandberg, K., Timmermans, B., Overgaard, M., & Cleeremans, A. (2010). Measuring consciousness: Is one measure better than the other? *Consciousness and Cognition, 19*(4), 1069–1078.

Schlaghecken, F., & Eimer, M. (2004). Masked prime stimuli can bias "free" choices between response alternatives. *Psychonomic Bulletin & Review (pre-2011), 11*(3), 463–468.

Schlaghecken, F., Klapp, S. T., & Maylor, E. A. (2009). Either or neither, but not both: Locating the effects of masked primes. *Proceedings of the Royal Society B: Biological Sciences, 276*(1656), 515–521.

Schneider, W., Eschman, A., & Zuccolotto, A. (2002). *E-prime user's guide*. Pittsburgh: Psychology Software Tools.

Schneider, W., & Shiffrin, R. M. (1977). Controlled and automatic human information processing: I. Detection, search, and attention. *Psychological Review, 84*(1), 1.

Sidis, B. (1898). *The psychology of suggestion*. D. Appleton & Company.
Snodgrass, M., Bernat, E., & Shevrin, H. (2004). Unconscious perception: A model-based approach to method and evidence. *Perception & Psychophysics, 66*(5), 846–867.
Snodgrass, M., & Shevrin, H. (2006). Unconscious inhibition and facilitation at the objective detection threshold: Replicable and qualitatively different unconscious perceptual effects. *Cognition, 101*(1), 43–79.
Stroh, M., Shaw, A. M., & Washburn, M. F. (1908). A study in guessing. *The American Journal of Psychology, 19*(2), 243–245. http://dx.doi.org/10.2307/1412764.
Van Gaal, S., de Lange, F. P., & Cohen, M. X. (2012). The role of consciousness in cognitive control and decision making. *Frontiers in Human Neuroscience, 6*, 121. http://dx.doi.org/10.3389/fnhum.2012.00121.
Van Gaal, S., & Lamme, V. A. F. (2012). Unconscious high-level information processing implication for neurobiological theories of consciousness. *The Neuroscientist, 18*(3), 287–301. http://dx.doi.org/10.1177/1073858411404079.
Van Gaal, S., Lamme, V. A. F., & Ridderinkhof, K. R. (2010). Unconsciously triggered conflict adaptation. *PLoS ONE, 5*(7), e11508. http://dx.doi.org/10.1371/journal.pone.0011508.
Weibel, S., Giersch, A., Dehaene, S., & Huron, C. (2013). Unconscious task-set priming with phonological and semantic tasks. *Consciousness and Cognition, 22*(2), 517–527. http://dx.doi.org/10.1016/j.concog.2013.02.010.
Weiskrantz, L. (2009). *Blindsight: A case study spanning 35 years and new developments*. OUP Oxford.