Preferential Unconscious Attention to Pictures Over Words in a Visual Recognition Paradigm

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Abstract

While prior literature has demonstrated the existence of unconscious attention, differences in processing disparate forms of visual stimuli have yet to be investigated. The present study aimed to determine whether unconscious attentional processing is preferential for pictorial or textual stimuli. Using an adaptation of Posner's (1980) spatial cueing paradigm, we tested subjects' (N = 25) ability to identify the location of unconsciously presented words and pictures. Participants were significantly faster and more accurate when locating consciously and unconsciously presented pictures, indicating preferential attention to pictorial over textual stimuli. This preference may be due to the increased evolutionary importance of pictures, or to a proposed greater allocation of cognitive processing networks (Paivio, 1986). In any case, the results of this study encourage further research of the influence of stimuli characteristics on unconscious attention, as it may prove relevant to academic and commercial fields alike.

Keywords: **spatial cueing paradigm, stimuli characteristics, preferential unconscious attention.**

Introduction

The relationship between consciousness and attention has been a subject of much debate (van Boxtel et al., 2010; Tallon-Baudry, 2012). Some theorists argue that they are entirely separate (Lamme, 2006; Cararra-Augustenborg, 2013), while others go so far as to equate the two (Baars, 2005; Damasio, 2003). However, over the last few years, there has been an abundance of research indicating that consciousness and attention are separate entities, supporting the existence of both conscious and unconscious attention (Heemskerk et al., 1996; Naccache et al., 2002; Kentridge et al., 2004; Montaser-Kouhsari & Rajimehr, 2004; Jiang et al., 2006; Sato et al., 2007; Chen et al., 2015; Prasad & Kumar Mishra, 2019). Accordingly, current research is centred around the characteristics of unconscious attention and its capabilities.

Researchers of unconscious attention tend to differentiate between bottom-up and top-down processes, particularly because the former is especially rapid to develop and dissolve in an unconscious attention context (Mulckhuyse & Theeuwes, 2010). Some have proposed that expectations and goals have an important impact on attentional orienting (Mulckhuyse & Theeuwes, 2010), while others advocate exogenous stimuli can successfully capture attention without explicit awareness (McCormick, 1997). Furthermore, some studies have even suggested that top-down and bottom-up processing may be inextricable due to mutual moderational influences (Chen et al., 2015). Despite these incongruencies, unconscious attention studies generally tend to use similar cueing methodologies, including the masked priming and spatial cueing paradigms (Prasad & Kumar Mishra, 2019; Posner, 1980). More than just validating the presence of unconscious attention, they can also be utilized to answer another lingering set of questions in this area of research: What aspects of a stimulus can be processed unconsciously, and are stimuli with certain characteristics processed preferentially?

Researchers have attempted to answer this question using the comparison of conscious attention to words versus pictures, with some researchers advocating for a picture superiority effect (Paivio & Csapo, 1973). For example, a study by Miller (2011) found that participants completing an attention task had faster reaction times for pictorial stimuli than textual stimuli. He proposes this may be because words are categorized as a unique form of visual stimuli due to their semantic content, leading to less efficient cognitive processing. However, Miller also proposes that task demands seem to have a significant effect on processing. Contrastingly, a study by Amrhein et al. (2002) did not find evidence for the picture superiority effect, and subsequently shed skepticism on pictorial stimuli's privileged processing. To our knowledge, no study has determined whether this attentional difference explicitly applies to unconscious stimuli. Therefore, this study seeks to fill that gap in the literature by examining the difference in unconscious attention for stimuli with different characteristics presented in the same task.

In the present study, we aim to determine whether unconscious attentional processing is preferential for pictorial or textual stimuli. This research question is assessed using an adaptation of the spatial cueing task from Posner (1980) that measures participants' reaction times (RT) and accuracy when identifying the location of unconsciously presented pictures and words. Our hypotheses are: (i) RT will be lower and accuracy will be higher for questions regarding consciously presented stimuli compared to questions regarding unconsciously presented stimuli; (ii) RT for questions regarding unconsciously presented pictures will be faster than that of unconsciously presented words; (iii) accuracy will be higher for questions regarding unconsciously presented pictures than that of unconsciously presented words. The latter two hypotheses were predicated on research of the picture superiority effect for conscious perception (Paivio & Csapo, 1973).

Methods

Participants

Participants were recruited from the Danish Institute for Study Abroad in Copenhagen. There were 25 in total, all between the ages of 20 and 22 (M = 20.88, STD = 0.53; 16 female, 8 male, 1 non-binary). Most participants had either normal or corrected-to-normal vision. Those without corrected-to-normal vision (N = 3) had myopia and could see the materials clearly without corrective lenses.

Paradigm

We used an adaptation of the spatial cueing design first described by Posner (1980). The paradigm was created using E-prime software (Psychological Software Tools, Pittsburgh, Pennsylvania, USA). Each participant sat 90 cm away from a computer monitor, with the height of the monitor adjusted to be centred in their visual field. Participants were first presented with a screen containing a black and white, 5” x 5” (12.7 cm x 12.7 cm), four-quadrant grid containing a 1” x 1” (2.54 cm x 2.54 cm) red cross in the centre for 1000 ms (Figure 1). Following this, a cue (1.5” x 1.5” (3.81 cm x 3.81 cm) red star) was randomly presented in one of the four quadrants for 1000 ms. The subject was instructed to direct their attention toward the cue. Two words and two images positioned randomly within the four quadrants then flashed for 45 ms, a duration just above the conscious perception threshold (Rolls, 2004). This timing enabled participants to consciously attend to the cued stimulus, while unconsciously attending to the three uncued stimuli. The words used were all four-letter nouns to reduce differences in complexity, and the images used were of singular objects, obtained from an independent artist. Subjects were thereafter asked to identify the location of one of the four stimuli using the W, C, M, and O keyboard keys, each corresponding with one of the four quadrants, as quickly and as accurately as possible. These four keys were chosen because, with stimuli presented for such a short duration, they needed to be physically separate (meaning participants used a different finger to press each key), spatially correspond to the quadrants, and be roughly equidistant. After answering this question, the blank quadrant with the red cross immediately returned, and the next trial began.

Participants completed two practice trials. In these practice rounds, subjects were only asked about stimuli in the cued quadrant, and they were given immediate feedback on the accuracy of their responses. All subjects thereafter completed a total of 24 real trials in randomized order. Eight of the trials required the participant to locate the stimulus that was in the cued quadrant. These trials (referred to as "cued" trials), therefore, had valid cues, and the participants' responses would reflect conscious attentional processing. For the other 16 trials (referred to as "uncued"), they were asked to identify the position of a stimulus in one of the three uncued quadrants. Thus, the cues were invalid, and the participants' responses reflected unconscious attentional processing. All subjects had been instructed before beginning that only questions asking about stimuli in the cued quadrant would count towards their final score. All four quadrants, stimuli types (pictures versus words), and directionality of cue versus question (i.e., top left to bottom left, top left to bottom right, etc.), were equally represented in the questions about uncued quadrants. Moreover, for each question, the stimulus was presented the exact way it was shown in the grid (i.e., when asking about a word, it was

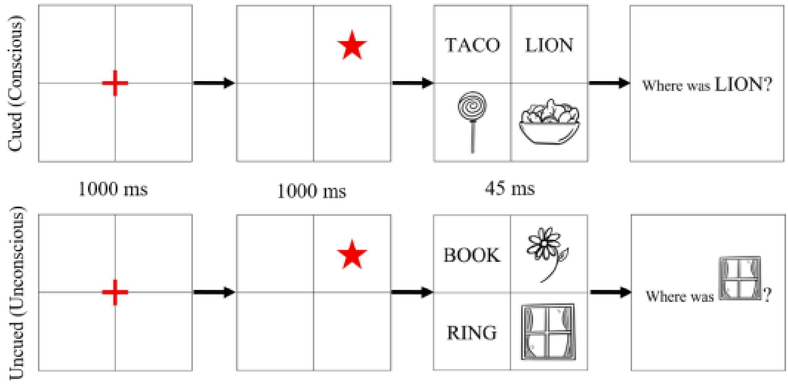

Figure 1. *An example of our spatial cueing paradigm. "Cued" trials asked the participant to locate stimuli in the cued quadrant (valid cues, conscious processing). "Uncued" trials asked the participant to locate stimuli from any of the three uncued quadrants (invalid cues, unconscious processing).*

presented in the same font and size, and when asking about a picture, the picture itself was used in the question).

Data Analysis

Data analysis consisted of a combination of paired two-sample t-tests assuming equal variances, paired two-sample t-tests assuming unequal variances, simple linear regressions, and chi-square tests. Analysis and figures were generated on Excel Version 16.43. All computed means were simple arithmetic means.

Results

Data Validation

A metric of validity composed of two criteria was employed to assess the success of the paradigm. To meet the first criterion, participants must have performed with above-chance accuracy on the cued trials to confirm that conscious attention was utilized. 19 of the 25 participants satisfied this crucial criterion. The second layer of the metric required a significant difference in accuracy between trials with valid and invalid cues to likewise indicate dissociated forms of conscious and unconscious processing. Four of the remaining participants satisfied this criterion, leaving two subjects who neither performed above chance on the cued trials nor performed significantly differently in the two conditions. Because 92% of participants satisfied at least half of the validity metric, it was assumed that the paradigm functioned as planned and no participant was omitted.

Additionally, accuracy concerning exposure to the paradigm was modeled by linear regression with trial number as a predictor for accuracy. The model was statistically insignificant ($R^2 = .02$, $F(1, 22) = .08$, $p < .05$). This confirms that accuracy did not increase as a function of practice, and accuracy could be assessed through the measures of interest rather than as a product of learning.

Accuracy

Across all conditions, participants performed significantly better when asked to locate a picture ($M = .6133$, $Var = .237$) than a word [($M = .35$, $Var = .228$), $t(598) = 6.68$, $p < .0001$].

As shown in Figure 2, this trend was maintained in the conscious cued condition [M(pictures) = .69, M(words) = .36, Var(pictures) = .216, Var(words) = .232, $t(198) = 4.96$, $p < .001$]. Likewise, in the unconscious uncued condition, responses to questions about pictures were significantly more accurate ($M = .575$, $Var = .345$) than responses to questions about words ($M = .345$, $Var = .227$, $t(397) = 4.73$, $p < .001$; Figure 2). The reported means refer to the percent of accurate responses for each participant across all 24 trials.

Reaction Time

Participants were overall faster when attempting to identify the location of a picture ($M = 1.3$, $Var = 360.8$) than that of a word ($M = 1.6$, $Var = 400.8$, $t(598) = -6.38$, $p < .001$). Similarly, reaction times were

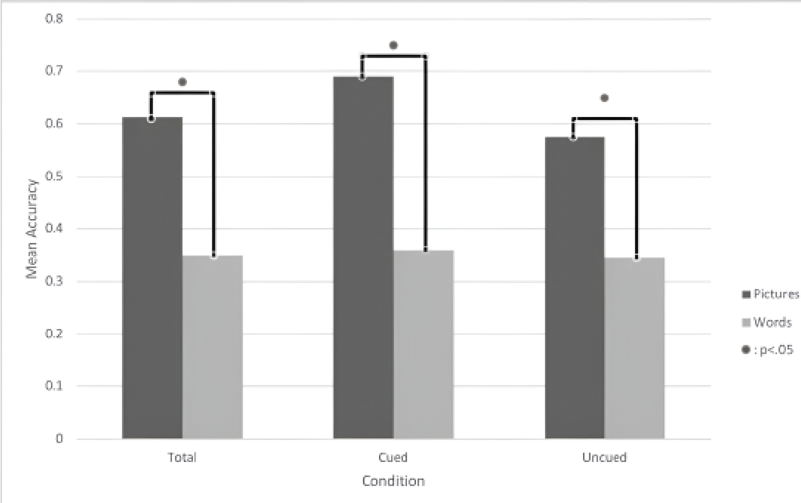

Figure 2. *Accuracy in the general picture vs. word condition, as well as in the cued and uncued conditions. A significant difference was found between words and pictures in every condition.*

lower for cued pictures (M = 1.2, Var = 264.6) than for cued words (M = 1.5, Var = 338.6, t(195) = -3.58, p = .0002). When identifying the location of figures that were unconsciously attended, participants were faster when asked about a picture (M = 1.3, Var = 408.5) than when asked about a word (M = 1.7, Var = 427.1, t(398) = -5.3, p < .001; Figure 3).

Quadrant Analysis

A post-hoc analysis of cue location revealed that when participants were prompted to look at the left side of the screen, they identified the location of the stimuli asked about with higher accuracy (M = .547, Var = .249) than when the cue was in one of the two right-side quadrants (M = .417, Var = .244, t(299) = 3.22, p = .0007). A chi-square analysis of each quadrant compared against the three others revealed that, for 3 out of the 4 tests comparing a left-sided cue to a right-sided cue, performance was significantly better when the cue was on the left side (Table 1). Conversely, there was no significant

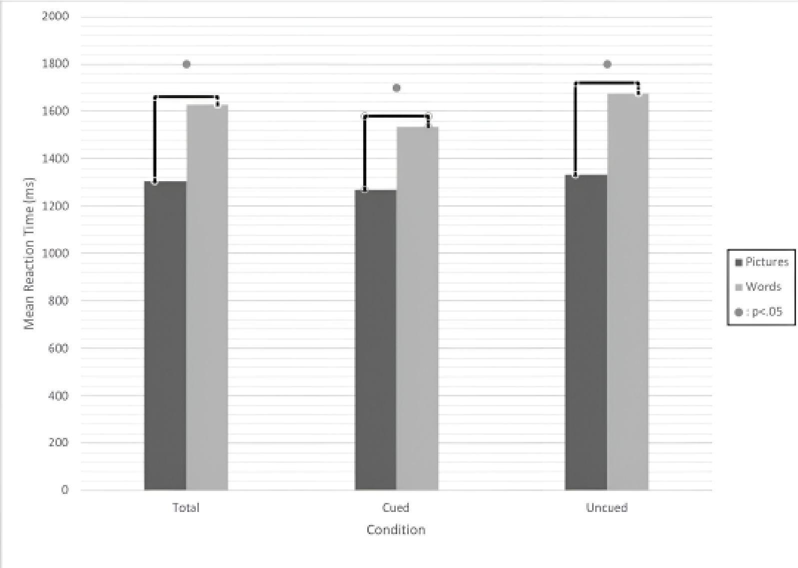

Figure 3. *Mean reaction times in the general picture vs. word condition as well as in the cued and uncued conditions. A significant difference was found between words and pictures in every condition.*

mean difference in accuracy rate when the compared cues were unilateral and above/below each other.

A closer look at the left-cue superiority effect depicted that improved performance when the cue was on the left-hand side applied when the figure asked about was a picture but not a word (Figure 4).

Therefore, only when the question asked about a picture, participants responded with greater accuracy when the cue was presented on the left side of the screen than when the cue was presented on the right side of the screen [(M = .69, Var = .215), t(298) = 3.336, p = .0004].

Discussion

These results contribute to a growing body of literature that corroborates the presence of unconscious attention and supports research suggesting consciousness and attention are distinct processes that likely rely on unique neural mechanisms (Chen et al., 2015). Moreover, as subjects were explicitly instructed to attend only to cued quadrants yet performed significantly better than chance when identifying the location of uncued picture stimuli, their performance supports previous findings demonstrating unconscious attention to exogenous cues (McCormick, 1997). Conversely, these results contradict previous studies suggesting task-relevant cues that match top-down goals are necessary to produce an efficient reaction time and high level of accuracy (Ansorge & Heumann, 2006).

Participants demonstrated preferential unconscious attention to

Cue Comparison	p-value	Location Comparison	Significant
Cue 1 vs. Cue 2	0	left right	*
Cue 1 vs. Cue 3	0.743	up down	
Cue 1 vs. Cue 4	0.05	left right	*
Cue 2 vs. Cue 3	0.005	left right	*
Cue 2 vs. Cue 4	0.102	up down	
Cue 3 vs. Cue 4	0.102	left right	

Table 1: *Comparison of mean accuracy with respect to cue location. Quadrants and cue locations are labeled 1-4 clockwise. Significant differences ($p < 0.05$) occurred between cues that differed laterally*

pictures over words, as evidenced by their significantly greater accuracy and significantly lower response times when identifying uncued pictures compared to uncued words. There are several possible explanations for this finding. First, from an evolutionary perspective, filtering potential threats in the surrounding environment largely depends on processing images rather than words (e.g., an image resembling a snake presents more potential danger than the word "snake"). Therefore, unconsciously attending to pictures—and filtering whether they necessitate further conscious attentional resources—may have provided an evolutionary advantage and thus been selected for over time (Yorzinski, 2014). Paivio's (1986) dual-coding theory may also explain the observed results. He argues that

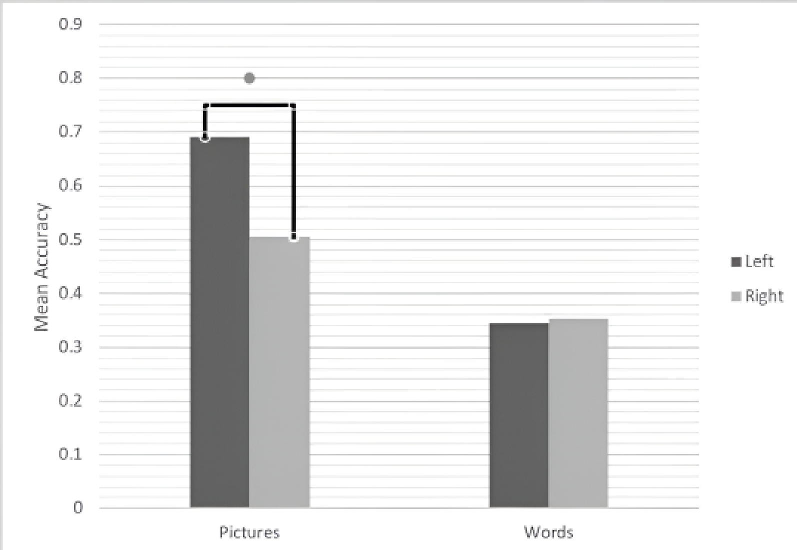

Figure 4. *Mean accuracy for questions asking about pictures and words, depending on if the cue was on the left or right side of the screen. Performance was significantly better for questions regarding pictures when the cue was presented on the left. There was no significance in accuracy between left and right cues when the participant was asked to locate a word.*

information can be processed by verbal or visual networks. While textual stimuli can only be processed by verbal networks, pictorial stimuli can be processed by both, as pictures inherently have a verbal counterpart. Thus, there may be preferential unconscious attention for pictures because they are processed through two networks, allotting these stimuli more cognitive resources. It can therefore be hypothesized that either there is a lower threshold for unconsciously attending to pictorial stimuli, or that pictures may have a more robust and/or direct line of processing compared to words. It is also worth noting that within the cued stimuli, which were above the threshold for conscious perception, participants also displayed a higher accuracy and lower response time for pictures, suggesting preferential attentional processing for pictures over words even consciously.

One unanticipated result was that left-sided cues predicted a higher mean accuracy of response for questions regarding pictures. This finding could potentially be explained through the activation-orienting hypothesis for the contralateral direction of attention (Reuter-Lorenz et al., 1990), in conjunction with Kinsbourne's Orientation Model for right hemisphere (RH) attentional dominance (1993). According to the activation-orienting hypothesis, which is experimentally supported by Reuter-Lorenz et al. (1990), the brain directs attention contralaterally to the more activated hemisphere. This attentional directing mirrors the contralateral nature of visual processing. Kinsbourne (1993) corroborates the finding of Reuter-Lorenz et al. (1990) but elaborates that within the brain's vectors of attention to the contralateral visual field, the left hemisphere's (LH) vector is more strongly biased towards the right visual field (RVF), while the RH is more generalized to include both the LVF and RVF. As a result, Kinsbourne (1993) proposes that the RH is dominant for attention, as its vector directs attention to both visual fields, while the LH only directs attention to the RVF. In the context of our experimental paradigm and results, it is possible that left-sided cues activated the RH and therefore enabled attention to be directed to the entire visual field, resulting in a higher mean accuracy of responses. Conversely, right-sided cues activated the LH and directed attention almost exclusively towards the RVF, therefore lowering accuracy over the entire visual field. As pictures appear to be preferentially unconsciously attended to in comparison to words, this model likely had a disproportionately greater impact on those stimuli.

We anticipated that a potential limitation of our study would be ensuring that participants followed directions and oriented their attention to the cued quadrant (and, by extension, that the rest of the stimuli were attended to unconsciously). In response, we took multiple measures to mitigate this risk. First, we instructed participants before beginning that only questions regarding quadrants containing the red star would count towards their "final score". Second, the speed with which the successive trials were conducted likely prevented participants from forming and implementing a thorough strategy. Lastly, as all the stimuli were presented barely above the threshold for conscious perception, consciously attending to the cued stimulus and all three uncued stimuli simultaneously seems unlikely, if not impossible. These efforts appeared to have successfully mitigated this potential limitation, as accuracy did not increase as a function of trial number, confirming the absence of a learning curve or practice effect. Most participants' significantly higher rate of accuracy when asked about cued, in comparison to uncued stimuli, also endorses that most followed instructions. That being said, it is possible that the two subjects who did not satisfy the criteria for validity (as they did not have a significant difference between response accuracy to cued and uncued stimuli) may have been directing their attention toward uncued quadrants.

There are, however, additional limitations to our study that may have affected our results. To start, there is a possibility that once subjects realized questions were being asked about uncued quadrants, instead of remaining a completely bottom-up task, there was a shift to making all stimuli task-relevant and thus subject to top-down processing (even if still unconscious). We can therefore not be completely confident whether our findings extend only to bottom-up attention, or a combination that also includes top-down. Additionally, despite being an adaptation of the Posner cueing task, this paradigm is new and could benefit from further testing to ensure its validity. Moreover, although our images were obtained from an independent artist, and thus had a similar style, there were apparent differences in the complexity of each image. In addition to varying levels of complexity between pictures, many of the pictures also contained more features than the words, which may have influenced the participants' attentional orienting. As a future direction, we propose a study design that standardizes the complexity—as measured by the number of features—of the images and words used.

Future studies could also investigate the influence of emotional valence on unconscious attention. Earlier, we proposed the difference in attentional processing may be evolutionarily based; a study examining whether there are differences in unconscious attention toward attractive or aversive pictorial and textual stimuli could help evaluate the accuracy of that claim. Finally, regarding practical applications, the results of this study could be utilized by neuromarketing firms. Conscious and unconscious attention were preferentially directed towards pictures, indicating that graphics may be more crucial than text when advertising a product. Neuromarketing research could further examine how to best implement this principle to create more efficient marketing for businesses.

Conclusion

Although the presence of unconscious attention is becoming increasingly acknowledged—and is supported by our findings—the specificities of this form of processing have yet to be thoroughly studied. Our results build upon literature in this field by uncovering a novel component of unconscious attention: its preferential treatment of pictures over words. We have provided several explanations for this finding, as well as proposed an interpretation for why left-sided cues coincided with higher accuracy of responses to pictorial stimuli. Future research should investigate the impact of feature number, emotional valence, and other aspects to further elucidate the effect of stimuli characteristics on unconscious attention. Understanding how humans process stimuli at this most basic level will prove useful for both academic and practical purposes as results can be applied to a wide variety of subjects, from theories of consciousness to neuromarketing strategies.

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