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Illusion processing in hemispatial neglect

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Abstract

Twelve patients with hemispatial neglect and two control groups were tested to examine the effects of the Müller-Lyer and Judd illusions on bisection behaviour. The studies were designed to investigate whether neglect patients were indeed unaware of the left sides of the illusory figures. In Experiment 1, participants were asked to describe the illusory figures prior to bisection, whereas in Experiment 2, they compared two illusions whose fins, in the critical condition, differed on the left and then performed the bisection. It was found that the illusions worked equally well in all three groups. Interestingly, apart from one exception, almost all neglect patients explicitly reported the left-sided fins in Experiment 1. Only five patients failed to do so but only on an average of 16% of trials. In Experiment 2, six patients made errors in the comparison task but four of these patients did not neglect any left-sided fins in Experiment 1 (with the exception of three overall trials for LC and EdR). This finding seems a good indication that the two tasks differ in their requirements. The comparison task may be perceived as harder as it requires discrimination rather than detection and thus lead to more neglect type errors than the bisection task. In one neglect patient, the illusions consistently failed to work. This patient presented with an occipito-temporal and basal ganglia lesion and the mechanisms responsible for the processing of simple visual features might have possibly been impaired in her case.

Keywords: Line bisection; Implicit processing; Awareness; Attention

1. Introduction

Dissociations between implicit and explicit processing have been observed in a range of neuropsychological syndromes such as amnesia, blindsight and aphasia [47], and it is clear that stimuli of which patients are not explicitly aware can nevertheless be used implicitly to influence the processing of other information. In relation to the clinical syndrome of hemispatial neglect, a study by Berti and Rizzolatti [7], in which primes were presented to the overtly neglected side, showed that these stimuli facilitated responses to the stimuli presented on the normal side. Additionally, patients who exhibit neglect dyslexia seem to process information on the neglected side as they substitute letters on the left side of words and form alternative words of about the same length as the stimulus word [21]. In a study by Peru et al. [42] pre-attentive processing was also observed for the perception of chimeric figures. For overviews regarding this issue see Ellis et al. [16], Karnath and Hartje [31] and Driver and Mattingley [15].

Interestingly, the subject of implicit processing in hemispatial neglect can also be addressed with perceptual illusions such as the Müller-Lyer and Judd illusory figures. Two such studies, one single case [46] and one group study [34], have so far been carried out. Both studies showed that the rightward bisection error typically shown by neglect patients could be altered by the illusions, in that bisections were displaced away from the baseline bisection error and shifted towards the outward-projecting fin and away from the inward-projecting fin. However, although this effect was clearly shown by Ro and Rafal's [46] patient, Mattingley et al.'s [34] group result proved less consistent: when presented with 100 mm lines neglect patients exhibited illusory effects in every condition except for unilateral

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left-sided inward-projecting fins; on 150 mm lines their bisection performance was influenced significantly by unilateral left-sided inward-projecting fins, unilateral right-sided outward-projecting fins and bilateral fins projecting to the right side, but for 200 mm lines no illusory effects were shown for unilateral left-sided fins, but only for unilateral right-sided outward-projecting fins and bilateral fins projecting to the left. Also, there were no significant differences between patients' bisection performance in the unilateral when compared to the bilateral conditions. If fins on both sides influence bisection behaviour one would expect patients to make greater bisection errors in the bilateral conditions. Mattingley et al. [34] argue that this lack of bisection difference between unilateral and bilateral fins cannot be explained by the phenomenon of extinction since extinction involves competitive interactions between separate objects. In the illusory figures used, fins and shaft were joined and formed a single object. It is thus not clear why inconsistent effects were found in this group study as such illusions "…have long been acknowledged to reveal hard wired circuits in the human visual system which mediate early vision" [46]. Since hemispatial neglect is generally believed to be a higher level disorder [25,36,45] these inconsistent findings are surprising and worthy of further investigation.

Indeed, Mattingley et al. [34] attributed the absence of significant illusory effects for left-sided outward-projecting fins at 200 mm lines to a reduction in the relative magnitude of fins as a function of increasing line length, as it had already been observed that the extent of illusory effects declines with increasing line length with outward-projecting but not inward-projecting fins [3]. When examining the individual bisection performance of their patients, they also found that some patients showed illusory effects of left-sided inward-projecting fins similar to those of controls, while others exhibited effects opposite to these. According to the authors these contrasting performances may reflect a qualitative difference in visual information processing of the left end of the line depending on type and location of lesion and time since injury, although they exclude directional hypokinesia as a possible cause, arguing that their data indicate significant differences in bisection errors as a function of stimulus type, a finding that would not be expected with such an impairment.

In terms of implicit processing, the authors argue that the fins on the neglected left side did sometimes influence the patients' bisection behaviour, despite the fact that they appeared not to perceive these. Unfortunately, Mattingley et al. [34] did not strictly test the lack of explicit awareness of left-sided fins in every patient: patients were simply asked to describe the figures on a pseudorandomized basis (only patient 1 and 2 had to describe all stimuli) after bisection. There is, thus, no hard evidence that the left side of the stimulus was indeed not explicitly processed.

This point was more stringently tested in Ro and Rafal's [46] experiment. To ensure the lack of explicit awareness of features on the left, their patient was first asked to complete a comparison task in which fins where either the same on the right and left, different on the right, or different on the left. The patient correctly judged 'same' for 23 out of 24 same pairs and 'different' for 11 out of 12 pairs, which differed on the right. For those pairs of illusory figures that differed on the left side only, however, she answered that they were the same for all 12 pairs. She was then asked to bisect the Müller-Lyer and Judd illusions and it was found that bisection errors were significantly affected by both illusions and that fins on the left had as much influence on the bisection errors as features on the right.

However, although Ro and Rafal [46] showed that their patient neglected the left-sided fins in the *comparison task*, it can not be ruled out that she was not explicitly aware of the left-sided fins in the *bisection task*. Two stimuli had to be attended to and discriminated in the comparison task, whereas only a single figure was present in the bisection task. Since task requirements are not the same in the two tasks, explicit attention may be distributed in different ways, possibly resulting in relatively larger neglect in the two stimuli as opposed to the single stimulus condition.

The purpose of the present two experiments was thus threefold: (a) to test patients with hemispatial neglect for explicit awareness prior to bisection in every trial of the experiment and then (b) to study the impact of explicitly neglected features on the left on the perception of the illusory figures. As shown in the single case study by Ro and Rafal [46] we expected the illusions to work in neglect patients even if they proved unaware of the fins, and we wanted to show this in a group study, as the Mattingley et al. [34] experiment yielded inconsistent results. In our first study, we used the same illusions as Mattingley et al. [34] but only one shaft length with the fin length being 36% of the shaft length. This was done to ensure that the ratio of fin length to shaft length was optimal to induce very strong illusory effects [19]. In this study, we also included the original Müller-Lyer figures in order to replicate the effect of perceived line length observed in Ro and Rafal's patient. In an additional manner, in the second investigation, we essentially replicated the Ro and Rafal experiment with a comparison and subsequent bisection task. This was done to investigate if the same group of patients may possibly show more neglect in the comparison task than in the task we gave them, i.e. the description of each illusion prior to bisecting it. Finally (c) we also included a patient control group in both experiments to be able to distinguish between the specific effects of neglect on illusion perception and the effects of right hemisphere lesions per se. Previous studies [2,28] have found similar illusory effects for right hemisphere-lesioned patients