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Selective attention, inhibition for repeated events and hemispheric specialization

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Abstract

When two visual events appear consecutively in the same spatial location, our response to the second event is slower than to the first. This inhibition for repeated events may reflect a bias toward sampling novel locations, a bias useful for exploring visual space. It has been shown that the left hemisphere is more specialized in selective attentional processes than the right one. The aim of the present experiment was to test if this hemispheric specialization for selective attention may also affect the inhibition for repeated events. For this purpose, we asked 11 normal subjects to perform an identity-based discrimination task in which the target to be detected could appear alone or surrounded by flanking letters, in the left or in the right visual field. Results show that inhibition for repeated events is present only when selective attention is required and when the task is performed in the right specialized visual field.

1. Introduction

Our visual system is overloaded constantly with information from the environment hence the advantage of efficient selective mechanisms for directing resources towards relevant stimuli.

Valid information about the location of an upcoming target can increase the speed and accuracy of responses, whereas invalid information produces a performance decrement (Klein & Taylor, 1994; Posner, Nissen, & Ogden, 1978). In examining the consequences of orienting attention, Posner and Cohen (1984) found that the same cueing condition is able to produce an early facilitatory process but also a later inhibitory effect. Within the first 150 ms following a peripheral cue, facilitation occurs at the cued location, with faster responses to cued targets than to uncued targets. On the contrary, around 300 ms an inhibitory effect occurs after the cue presentation, with uncued targets being responded faster to than cued targets. Posner and Cohen (1984) labeled this phenomenon 'inhibition of return' (IOR) to underline the notion that the visual system is biased in order to avoid returning to previously attended locations.

In the vast majority of studies upon the IOR phenomenon, the researchers used tasks in which the participants made responses that involved the detection of a single target stimulus presented at either a previously attended location or at a novel location. As pointed out by Pratt and Abrams (1999) only a few studies have examined this phenomenon in identity-based discrimination tasks. However, it is this type of task that people perform when searching the visual space for a specific target. As a matter of fact, despite some early evidence to the contrary (Tanaka & Shimojo, 1996; Terry & Valdes, 1994), there is now growing evidence that IOR may occur not only for responses based on the detection of a target, but also for responses that are based on the discrimination of the identity or the location of a target stimulus (Lupianez, Milan, Tornay, Madrid, & Tudela, 1997; Pratt, 1995; Pratt & Abrams, 1999; Pratt, Kingstone, & Khoe, 1994). Moreover, Chasteen and Pratt

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(1999) recently demonstrated that IOR may also occur in tasks that requires complex discrimination such as lexical decision and categorization tasks.

Although attention and inhibition for repeated events appearing at the same location are often assumed to be related, the nature of this relationship is not clear yet (Klein & Taylor, 1994; Rafal, Egly, & Rhodes, 1994; Taylor & Klein, 1998).

Recently, using a visual detection paradigm (Tabert et al., 2000) we demonstrated that when selective attention is required to identify a visual target surrounded by flankers, reaction times (RTs) are shorter in the right than in the left visual field (Chokron, Brickman, Wei, & Buchsbaum, 2000), thus confirming a left hemisphere (LH) advantage for filtering irrelevant information and analyzing the local features of a visual scene (Robertson & Lamb, 1991; Robertson, Lamb, & Knight, 1988). Conversely, RTs were found to be shorter in the left visual field (LVF) than in the right visual field (RVF) when the to-be-identified target was presented alone and required less filtering activity, that is less selective attention.

The present study sought to clarify the mechanisms underlying inhibition for repeated events by further exploring the idea that it is an attentional effect. For this purpose we used in the present experiment the same protocol as above mentioned and recorded the presence of inhibition for two visual events appearing consecutively in each condition of stimulus type and visual field of presentation. If the inhibition for repeated events is an attentional process, it should arise more clearly in the condition where selective attention is required, that is when the target to detect is surrounded by flankers inducing a filtering process. In addition, since the visual field of presentation was found to significantly interact with the stimulus type, we aimed to study here its influence on inhibition. On the other hand, if inhibition and attention are independent mechanisms, there should be no effect either of the stimulus type (alone or with flankers) or of the visual field of presentation (left or right) on the occurrence of inhibition.

2. Methods

2.1. Subjects

Eleven normal right-handed subjects (six men, five women) volunteered to participate in the study. Their ages ranged from 20 to 40 (average: 31.4), and they all had normal vision, and left-to-right reading habits and used the Roman alphabet.

2.2. Procedure

Subjects sat in a comfortable chair, directly in front of the middle of the computer screen and at a distance of 57 cm and looked at stimuli positioned horizontally at 2° to the right or to the left of the central fixation point.

During the whole experiment, subjects had to visually fixate a dot corresponding to the center of the screen and were presented 16 blocks, each of eight trials. Between each block, there was a 20-s period of rest while the screen was gray and subjects could close their eyes if they wished to.

Subjects were presented 128 visual stimuli, 64 in the left visual field and 64 in the right visual field. The stimuli were the letter O, the letter C, or the digit zero (0). The stimulus appeared either alone as a big character, or as a small character surrounded by eight other letters (see Fig. 1). The overall size of the stimuli was controlled so that the big letters were of the same dimensions as the pattern of small letters surrounded by flankers, that is, 19 mm wide × 22 mm high.

The subjects task was to click on the mouse each time they detected the letter O, either alone or surrounded by small letters, and to ignore the C and the 0. In case of the target appearing in the left visual field subjects had to click on the left button of the mouse, whereas they had to press on the right for a right-sided target. Each display was flashed for 150 ms. When the subject responded, a 2000 ms inter-trial interval began. If the subject did not respond, a 1000 ms delay ensued.

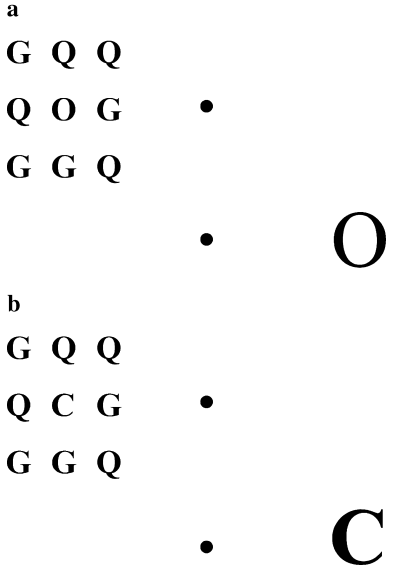

Fig. 1. Examples of stimuli displays. The target can be a small letter **o** surrounded by flankers (top) or a big letter **O** presented alone (bottom) (a). In half of the trials, the letter C or the digit zero (0) were presented as distractors (b). As for targets, half of the distractors were presented surrounded by flankers (top) and the other half alone (bottom). Each kind of stimulus (target or distractor, alone or surrounded by flankers) was presented equally in the left and right hemifield.

3. Data analysis

For each subject and each side of target location (left or right), we selected the pairs of successive trials that met the following constraints:

(1) The same target occurred in the same spatial location on both trials.
(2) The first target was not preceded by the same stimulus in the same location.
(3) Both responses in each pair were correct and fell in the range 150–2000 ms.

The reaction times (RTs) for these trials were evaluated by a four-way analysis of variance (ANOVA) with gender as a between subject factor and time of presentation (first or second trial of the pair), type of stimulus (alone or surrounded by flankers) and visual field (left or right) as within-subjects factors.

4. Results

As previously demonstrated (Chokron et al., 2000) single targets led to shorter RTs ($m = 343$ ms; $SD = 90$) than targets surrounded by flankers ($m = 462$ ms; $SD = 102$) ($t18 = 2.76$; $P < .05$). Also confirming previous results (Chokron et al., 2000), reaction times to single targets were shorter in the LVF ($m = 334$ ms; $SD = 55$) than in the RVF ($m = 352$ ms; $SD = 79$) while the reverse was observed for targets surrounded by flankers where a presentation in the RVF induced shorter RTs ($m = 450$ ms; $SD = 90$) than in the LVF ($m = 474$ ms; $SD = 103$).

Fig. 2 displays the response latencies for those pairs of trials in which two consecutive trials t1 and t2 correspond to the same target appearing at the same location. The ANOVA revealed a significant interaction between the type of stimulus, the visual field of presentation and the trial of the pair ($F1–10 = 5.99$; $P < .03$). This interaction stems from the fact that the only statistically significant difference between the RTs in the first and second trial of identical pairs occurred when the two successive trials corresponded to the target surrounded by flankers presented in the RVF (see Table 1). In this case, the response to t2 was 58 ms slower than the one to t1 ($F1–10 = 12.95$; $F < .005$). This latter condition is the only one in which inhibition for repeated events occurred. In the other conditions, instead of an inhibition, we observed a facilitation for the second trial of the pair which always led to shorter reaction times than observed for the first one, although none of these differences reached significance (see Table 1).

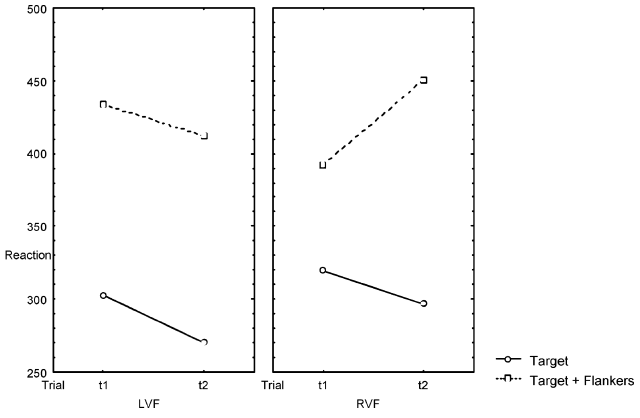

Fig. 2. Effect of the interaction between the type of stimulus (target or target + flankers), the visual field of presentation (left or right) and the trial of the pair of identical targets in the same location.

5. Discussion

Many authors have tested the attentional nature of inhibition for repeated events by trying to demonstrate that attention and inhibition might be similarly affected by some experimental factors. For example, Reuter-Lorenz, Jha, and Rosenquist (1996) argued that inhibition of return and attentional orienting share a common mechanism, because target modality, target intensity and response mode influence the magnitude of both attentional costs and benefits and the magnitude of inhibition of return. Recently we have demonstrated that when a filtering process is required to identify a target surrounded by flankers in the same protocol than the one used here, RTs are shorter in the RVF than in the LVF, confirming a left hemisphere advantage for some aspects of selective attention (Berlucchi, Aglioti, & Tassinari, 1997; Corballis, 1995; Proverbio, Zani, Gazzaniga, & Mangun, 1994). In the present experiment, we replicate this finding and showed that the only experimental condition where inhibition for repeated events

Table 1
Mean reaction times (ms) and standard deviations for each type of stimulus, visual field of presentation and trial

Target				Target + flankers			
LVF		RVF		LVF		RVF	
t1	t2	t1	t2	t1	t2	t1	t2
302 (52)	270 (54)	320 (65)	297 (93)	434 (85)	412 (92)	392 (115)	450 (125)

LVF, left visual field; RVF, right visual field. t1, First trial of the pair of two identical trials (same target and same location); t2, second trial of the pair of two identical trials (same target and same location).

arose is the condition where the stimulus is surrounded by flankers and is presented in the RVF, that is to the left hemisphere. According to this finding, inhibition for repeated events occurs when selective attention is required and especially when the information is presented to the left hemisphere specialized for this type of process. In the three remaining conditions, facilitation instead of inhibition was present for the second trial as compared to the first one. Although this facilitation did not reach significance, it evokes repetition priming, the fact that responses are generally facilitated when the stimulus on a given trial is the same as presented on the immediately preceding trial. The present results suggest that inhibition for repeated events would be present only for stimuli requiring selective attention and being responded to with the shortest RTs (when presented in the most specialized visual field). In other cases, repetition priming would be present.

Overall, our findings show that inhibition for repeated events does affect discrimination judgments especially when selective attention is required. When no filtering process is necessary to perform the task or when the filtering is performed in the non-specialized visual field, facilitation instead of inhibition is present. These findings support the notion that inhibition reflects an adaptive mechanism for efficient attentional searches. The fact that inhibition may depend on selective attentional resources as well as upon a kind of hemispheric specialization undoubtedly require some more research especially in the field of patients undergoing selective attention deficits, who may show as some of us demonstrated (Bartolomeo, Chokron, & Sieroff, 1999) asymmetric patterns of IOR.

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