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Effects of Perceptual Load and Distractors on Inhibition of Return

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ABSTRACT
To explore the influence mechanism of perceptual load and distractors on time course of inhibition of return, flanker interference and perceptual load levels were combined with the IOR paradigm using discrimination task. The participants's task was searching for the target and ignoring the distractors. The results showed that under high perceptual load, there was no IOR effect in the experiment, but the results at low perceptual load were inconsistent. There was significant IOR in short SOA (400ms) with low perceptual load when the distractors were consistent with the targets, but disappeared in long SOA with significant facilitation. According to the three-factor theory, the cue would cause the attention orientation of the cuing position, regardless of the distractors stimuli, "spatial selection benefit" and the facilitation appeared at short SOAs, while, it appeared "detection cost" and the IOR effect at longer SOAs.

Keywords: *Inhibition of Return (IOR), Discrimination task, Distractors, Perceptual load.*

1. INTRODUCTION

The perceptual load theory of Lavie et al [1-2] indicates that under high perceptual load, earlier selection attention occured, and under low perceptual load, later selection appeared. Under earlier attention selection, the distractors were not processed, and the response to the target did not be effected by the stimulus-response mapping of the target and the distractor; under later attention selection, the distractors were processed, the response to the target would be effeted by the consistency of interference term with the target.

The existence of interference effect was different at high perceptual load and low perceptual load. Is the time course of the Inhibition of return (IOR) influenced by perceptual load? IOR refers to a slowed response to targets appearing at attended locations[3]. In this study, the perceptual load paradigm and the IOR paradigm were combined to explore the effects of distractors and perceptual load on the time course of IOR.

2. EXPERIMENT

2.1. Participants

Participants were randomly selected from undergraduates, 4 males and 13 females. The 17 participants had normal vision or corrected vision, aged 19 ~ 22. All the participants were right-handed. The participants got some reward after the experiment.

2.2. Experiment Design

The experiment was designed with a 2*2*2*2 within-subjects variables. Variable 1 was cue, cued (the location of cue stimulus was the same as the location of target stimulus), and uncued (the location of cue stimulus was different from the location of target stimulus), variable 2 was SOA (400ms, 1000ms), and variable 3 was the level of perceptual load(low and high). Variable 4 was the consistency of the targets with the distractors(consistent, inconsistent). The participants were asked to response to letter"M" and "N" by pressing the left and right mouse button. The reaction time and accuracy of the subjects were recorded.

2.3. Stimuli

The central fixation was a white "+"with a height of 0.5 ° and a wide angle of view. The target appeared in one of four boxes. The visual angle of white box was 1.2 °. The visual angle from the center of the fixation to center

of the box was 3.5 °. The target was a white letter "M" with an angle of 0.5 °. It appeared randomly in one of four boxes. Under low perceptual load, three white "O" targets with an angle of 0.5 ° appeared in different white boxes at the same time. Under the high perceptual load condition, the white letters H, E, F and the target appeared at the same time. Distractors appeared on the up or down side of the screen. The distractors visual angle from the central fixation was 5.5 °.

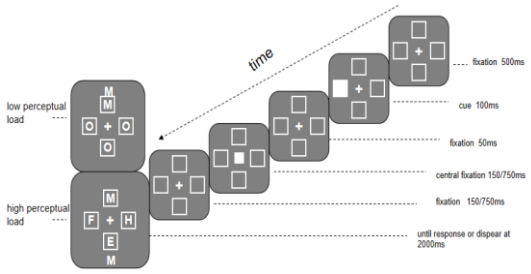

Figure 1 Example of sequence and timing of the trails in experiments.

2.4. Procedure

The participants needed to gaze at the central fixation throughout the experiment. There were 64 practice trails before the formal experiment. The formal experiment consisted of 768 trails. There were 2 kinds of time intervals, 150ms/ 750ms, after the central cuing. After every 96 trails, participants were allowed to take a rest. All possible combinations of cue and target location, and target letter variables were randomly presented within a block of trails.

2.5. Results

Trails with RTs shorter than 100ms or longer than 1068ms were excluded from the RT analyses. The results of experiment were illustrated in Fig.2 and Fig.3. RTs of were submitted into a repeated ANOVA. The reaction time of inconsistent experimental conditions minus the reaction time of consistent experimental conditions is the interference effect.

The results showed that there was a significant cuing effect, $F(1,16) = 4.77$, $p < 0.05$. RTs were slower to targets at the cued location than at the uncued lacation, which was typical facilitate effect. There was a significant SOA main effect, $F(2,32) = 10.33$, $p<0.001$, which indicated that the RTs at 400ms was significantly slower than that at 1000ms. There was a main significant perceptual load effect, $F(1,16) = 12.07$, $p < 0.01$. The RTs when perceptual load was high were significantly slower than when perceptual load was low, which indicated that perceptual load level was different. There was no significant difference at consistency of the targets with the distractors. There was a significan interaction effect between perceptual load and cueing, $F(1,16) = 7.09$, $p< 0.05$, and other interactions were not significant.

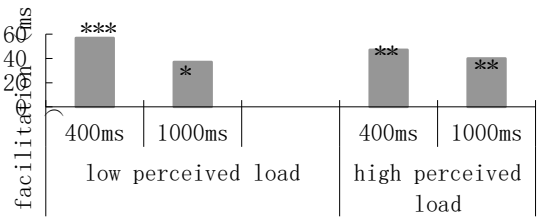

Figure 2 The facilitation results of experiment.

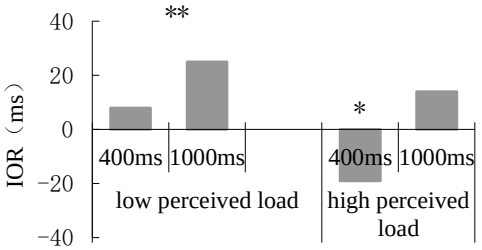

Figure 3 The IOR results of experiment.

To further explain the interaction on IOR under different perceptual load conditions, 2(consistency)*2(SOA)*2(cue validity) ANOVAs were taken to analyze the variance under different perceptual load. At high perceptual load, there were significant main effect at SOA and cue validity, $F(2,32) = 9.67$, $p <0.001$, $F(1,16) = 8.27$, $p < 0.01$. The RTs at 400ms were significantly slower than that at 1000ms, and the main effect of cuing was significant. When perceptual load was low, the main effect of SOA was significant, $F(2,32) = 5.11$, $p < 0.05$. The main effect of cueing location was not significant, and there was no significant IOR. To further explore the temporal characteristics of IOR in different SOAs, the paired sample t tests were performed for cued and uncued. When perceptual load was high, significant facilitation appeared at 1000ms. When perceptual load was low, the IOR effect was significant at 400ms when the target and the distractors were consistency, while the facilitation was significant at 1000ms. In order to compare the interference effects of high and low perceptual load, the paired sample t test was used. When perceptual load was high, all the interference effects did not reach the significant level. At low perceptual load, the distractors effect of uncued position was reversed significantly at 1000ms.

3. DISCUSSION

The results showed that under low perceptual load, there was significant IOR only at 400ms when the targets and distractors were consistent, when the SOA was 1000ms, there were significant facilitation. When the SOA was 400ms, there was no significant IOR under either high perceptual load or low perceptual load conditions, the results were consistent with those of previous studies on inhibition of return [4-5]. Under low

perceptual load task, when the SOA was 1000ms, however, there is no significant IOR effect. When perceptual load was high, the IOR was not significant, a lot of attention resources should be used to response to the target, and few extra resources could be used to process the distractors. The different effects of distractors on target processing under different perceptual load were consistent with the view proposed by Lavie et al [2].

Previous studies have found that whether perceptual load is high or low has little effect on target processing under cued conditions [6]. Under the uncued condition, the position of cuing was not consistent with that of targets. When participants found this inconsistency, they looked for the target stimulus in other locations. In the process of searching for the target stimulus, the distractors would be processed. When perceptual load was low, only part of the attention resources was needed to process the target, and the rest of the attention resources would spill over automatically to process the distractors, which following a large distractors effect. However, the distractors' effect was only significant at the uncued position of 1000ms under low perceptual load, which was consistent with previous studies. At low load, the remaining resources would automatically be spilled out to process the distractor stimulus only at long SOAs, on the other hand, the cuing time in this study was different from that in the previous studies.

Lupiáñez et al(2004, 2009)proposed "three factors theory" to explain the time course of IOR. There were three parallel processes when simulus were processed[7-8]. "Spatial orienting benefit" refers to the peripheral cues trigger a short-live dexogenous spatial orienting of attention, that process is usually considered for explaining cuing effects. After the cueing representation, however, two different processes would follow when participants detected the onset of the target: "onset detection cost" and "spatial orienting benefit". The sum of the three factors would result in facilitation or inhibition of the peripherally cued targets. In discrimination tasks, spatial selective benefits would produce a marked effect that result in more facilitation, whereas the detection costs would result in inhibition in detection tasks.

According to the three-factor theory, it can be expected that because all the experimental conditions were the same before the target was presented, the cue-stimulus presentation would cause the attention orientation of the cuing position, facilitation of the response to subsequent stimuli at that location, after cuing, and then the same effect on subsequent stimuli at the cuing location would be occured, the shorter SOA had the "spatial selection benefit" and the facilitation effect, while the longer SOA had the "detection cost" and the IOR effect. According to three-factor theory, when perceptual load and distractors were added in the experiment, the task becomed more difficult, the participants also need more attention resources, and the IOR should appear later or disappear. The analysis of the interference effect and the facilitation effect showed that the interference effect was significant only at the uncued position at 1000ms, the interference effect did not appear at the short SOA, because participants needed to focus all attention resources to the task, there was no extra resources to process the distractors, and when the SOA was long, the participants had plenty of time to adjust their attentional [10]. The facilitation effect was only significant at a cueing location at 1000m, and the peripheral interference was consistent with the target during the long SOA, facilitating target processing. Both the interference effect and the facilitation effect were not significant under high perceptual load.

4. CONCLUSION

The results showed that there were different results on different perceptual load, there was no significant IOR at 400ms when targets and distractors were in consistent, while there was significant IOR when the targets and distractors were consistent, when the SOA was 1000ms, there were significant facilitation. "Three factors theory" could be used to explain the results. In this experiment, the task becomed more difficult because perceptual load and distractors were added, the IOR appeared later or disappear.

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