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Distractor inhibition for object and action selection

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We conducted two experiments to investigate the factors that determine our ability to select objects based on the stimulus properties and actions based on the response properties. Riddoch, Humphreys, and Edward (2000) reported data from a brain-damaged patient, suggested the inhibition effect of the distractor varied dependent on the stimulus-response association, that is, response blocking effect. In the present study, healthy participants viewed two arrows, or one arrow and one bar in a horizontal position. Before this display, an endogenous cue was presented in order to indicate the dimension to be selected and responded the direction of the target arrow or the location while ignoring the distractor. We manipulated the inhibition effect defined by the target and distractor stimulus, and the compatibility effect defined by the target stimulus and -associated response. As a result, the response blocking effect was observed by healthy participants. And the occurrence of this effect was dependent on task switching. These results suggest that the stimulus-response association decide the object and action selection.

Keywords: distractor inhibition, object-action association, selection, task switching.

Introduction

We investigated the factors that determine our ability to select objects based on the stimulus properties and actions based on the response properties in a variety of the environments. Riddoch, Humphreys, and Edwards (2000) reported data from a patient with cortical basal degeneration, suggested the inhibition effect of the distractor occurred only in the compatible condition between the stimulus and responding hand. This effect was described as the response blocking effect, because the inhibition of the distractor blocked the action evoked by the target stimulus. According to Humphreys and Riddoch (2000), the mechanisms of this response blocking are caused by object-action assemblies, which are longer-lasting links between the object and action evoked eventually by the object. Furthermore, Monsell, Yeung and Azuma (2000) suggested that task repeating or switching was related with association between stimulus and response to configurate a task-set.

In the present study, healthy participants viewed two arrows or one arrow and one bar in a horizontal position. Before this display, an endogenous cue was presented in order to indicate the dimension to be selected and responded the direction of the target arrow or the location while ignoring the distractor. Each effect is defined by the relationship between; the target stimulus and distractor stimulus which are presented horizontally (the inhibition effect); the target stimulus and –associated response (the compatibility effect); the task repeating and changing the direction task or the location task (the task switching). The response blocking effect is manifested by the inhibition effect dependent on the compatibility. We explore (i) whether the response blocking effect occurs by healthy participants (ii) whether this effect is affected by task switching or not. If task switching influenced on this response blocking effect, it would indicate that links between object and action, other than object-action assemblies, are the factor to determine object and action selection. The lasting of object-action link by reconfiguration of a task-set may be shorter than that of object-action assemblies.

Experiment 1

Experiment 1 was designed to examine if the response blocking occurs or not by healthy participants. We established either inconsistent condition, in which one right arrow and one left arrow were presented, or neutral condition in which one right or left arrow and one bar were presented, in order to measure the inhibition effect of the distractor. Furthermore, we classified between compatible response to the left (right) location by the left (right) hand and incompatible response to the right (left) location by the left (right) hand in order to define the compatibility effect. This effect serves as the stimulus-response association. If the response blocking effect occurred, it would be possible to observe the difference between the inconsistent and the neutral condition, namely the inhibition effect, only under the compatible condition.

Method

Participants. Twelve volunteers (8 males and 4 females; 20-24 years of age) participated. All reported normal or corrected-to-normal vision, and normal color vision. They were naive to the purpose of the experiment.

Apparatus. Stimuli were displayed at the center of a 22-inch color monitor (MITSUBISHI Diamondotron FlatRDF22P II) controlled by an AV-tachistoscope system (Iwatsu ISEL IS702). Response times were measured by means of a digital millisecond timer from the onset of target stimuli. Response time and accuracy were recorded.

Procedure. The experiment was run in a semi-darkened room. Participants viewed the monitor from a distance of 57 cm. One trial consisted of a fixation, a cue, a blank, and a target display (see Figure 1). Each trial began with the presentation of a fixation for 1000 ms. Immediately after the offset of a fixation, a cue was presented for 500 ms followed by a blank appeared for 1000 ms. Next, a target display was presented for 1000 ms, and then the fixation display reappeared, marking the start of the next trial. The participant's task was to respond a direction of the target arrow in which the location was indicated by a cue. An endogenous cue was presented in order to cue the participant that the target location would be the right ("VR") or left ("VL"). The order of the cue was randomized. Participants were required to respond by using two keys assigned to the dominant hand as quickly as possible while attempting to minimize errors. RTs to the target were analyzed. Participants were instructed to hold their gaze on the fixation display when it appeared. Responses to the target were made by pressing one of two keys, assigned to the first or second finger. Error feedback was provided on the target responses.

Analysis. The data were extracted from responses to randomly presented stimuli. The inhibition effect was defined as the difference in responses between neutral condition (one arrow and one bar) and inconsistent (one arrow and opposite direction arrow) condition. The measure of compatibility effect was decided by which the target location (left or right) is presented at the same (compatible) or the different (incompatible) to the responding key (left or right key). All conditions appeared randomly and equivalently.

Within-block factors were the consistency (neutral vs. inconsistent) and compatibility (compatible vs. incompatible). An experimental block consisted of 128 trials. Participants were tested individually for a practice block (64 trials) and five experimental blocks.

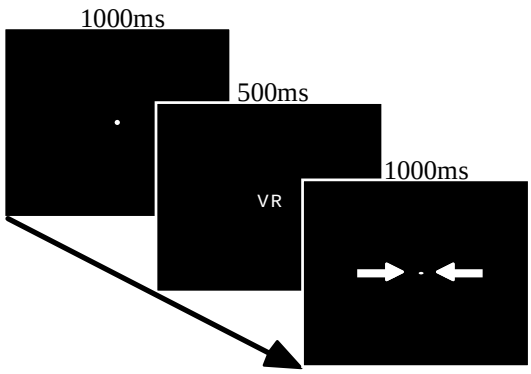

Figure 1. The display sequence of stimuli in all experiments.

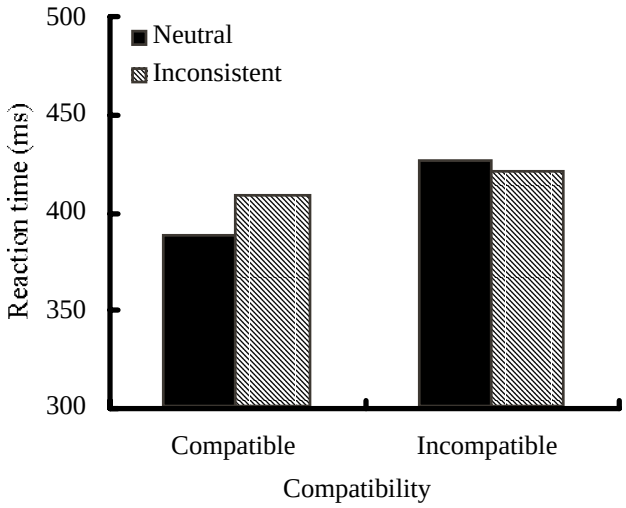

Figure 2. RTs for neutral and inconsistent conditions used in Experiment 1, shown for each compatible and incompatible conditions.

Results

With the exception of one participant with an error rate of over 10%, who were excluded from the data set, the mean error rate was 1.6% in all conditions. The error rates were analyzed by a two-way analysis of variance (ANOVA), with the consistency (neutral vs. inconsistent) and the compatibility (compatible vs. incompatible). Main effects and the interaction were not significant, indicating that there was no statistical evidence for a speed-accuracy tradeoff.

In this experiment and the subsequent experiment reported in this article, outliers on RTs were eliminated from further analysis using a moving criteria method (van Selst & Jolicoeur, 1994). Figure 2 shows mean correct RTs for each condition. The data were analyzed by a two-way ANOVA with the consistency and the compatibility. A main effect of compatibility was significant, F (1, 11) = 7.79, p < 0.03. The two-way interaction between consistency and compatibility was also significant, F (1, 11) = 11.25, p < 0.01. A post-hoc Tukey-test showed that RTs for the inconsistent condition were slower than those for the neutral condition only in the compatible condition (p < 0.03). The inhibition effect in the compatible condition was significant, but that in the incompatible condition was not. As can be seen from Figure 2, the inhibition effect varied with the compatibility condition.

Discussion

In the compatible condition, the difference between the neutral condition and the inconsistent condition, or the inhibition effect occurred. In the incompatible condition, this effect did not occur. These results show that the response blocking effect can be observed by healthy participants. In other words, the inhibition of the distractor varied dependent on the stimulus-response association.

This result is consistent with those of Riddoch et al. (2000). In Experiment 2, we explore the response blocking effect by healthy participants under task switching.

Experiment 2

Experiment 2 was designed to examine if the response blocking occurs or not under task switching. If the response blocking effect was observed dependent on task switching or task repeating, links between object and the action other than object-action assemblies would affect the response blocking effect. In order to measure task switching, we added the location task to the direction task used in Experiment 1.

Method

Participants. Fourteen volunteers (9 males and 5 females; 20-28 years of age) participated. All reported normal or corrected-to-normal vision, and normal color vision. They were naive to the purpose of the experiment.

Apparatus, Stimuli, and Procedure. Apparatus, stimuli, and procedure were the same as those in Experiment 1, except that as a cue, AR/AL was added to VR/VL. “AR” or “AL” was, like “VR” or ”VL”, presented at the center, with the former indicating that the target to be responded would be the right arrow (“AR”) and the latter indicating that it would be the left arrow (“AL”). An endogenous cue was presented in order to cue the participant that the target would be the right (“VR”) or left (“VL”) location or the right (“AR”) or left (“AL”) arrow. The participant’s one task was, when the cue was “VR” or “VL”, to respond a direction of the target arrow in which the location was indicated by a cue. The other task was, when the cue was “AR” or “AL”, to respond a location of the target arrow in which the direction was indicated by a cue.

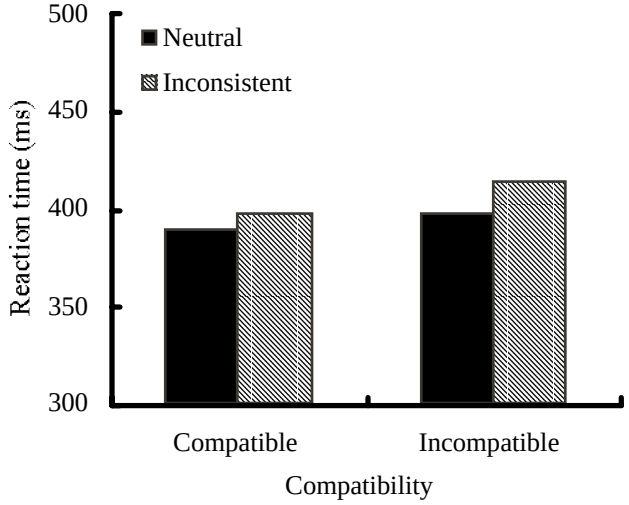

Figure 3. RTs for neutral and inconsistent conditions used in the direction task of Experiment 2, shown for each compatible and incompatible conditions.

Within-block factors were the consistency (neutral vs. inconsistent), compatibility (compatible vs. incompatible), and task switching (repeating vs. changing).

Results

There was mean error rate of 5.1% in the all conditions. In the same direction task as Experiment 1, mean error rate was 3.8%, whereas in the location task, mean error rate was 6.4%. A three-way ANOVA with consistency, compatibility, and task switching as the main terms showed neither main effects nor interactions suggesting that there is no statistical evidence for a speed-accuracy tradeoff.

Figure 3 shows the mean correct RTs for Experiment 2. The data were analyzed by a three-way ANOVA, with consistency, compatibility, and task switching for each the task. Mainly, in the location task, two main effects of consistency; F (1, 13) = 6.06, $p < .05$, and of compatibility; F (1, 13) = 5.30, $p < .01$, were significant. The main effect of task switching was not significant, F (1, 13) < 1. It is clear from these results that in this experiment also, there were the inhibition effect and the compatibility effect. However, the two-way interaction between consistency and compatibility was not significant, F (1, 13) < 1.

Discussion

The result of Experiment 2 was different from that of Experiment 1. First, the compatibility effect was observed. Second, the inhibition effect occurred regardless of the compatibility, the response blocking effect disappeared. These results indicate that the response blocking effect occurred dependent on task switching. Furthermore, the task switching cost did not occur.

General discussion

In the present study, we conducted two experiments to investigate the following questions; (i) whether the response blocking effect is observed by healthy participants; (ii) whether this effect is dependent on task switching or not.

Results of Experiment 1 described here clarified the inhibition effect dependent on the compatibility, that is, the response blocking effect. The inhibition effect, which responses for the inconsistent condition is slower than the responses for the neutral condition, occurred only in the compatible condition. On the contrary, this effect did not occur in the incompatible condition. These results suggest that the response blocking occurred by healthy participants. In Experiment 2 under task switching, the response blocking disappeared. So, the task switching bore on the response blocking effect.

Our results demonstrate that the response blocking is due to not only object-action assemblies but also link between object and action as task switching. Riddoch et al. (2000) suggested that the competition between the actions evoked by the stimulus and those based on the task instruction set

after the object selection. This competition for action was often won by the stimulus-associated hand. Furthermore, the mechanisms of this response blocking are considered to be caused by object-action assemblies, which are links between object and action (Humphreys & Riddoch, 2000). They proposed that there are longer-lasting representations of selected objects and actions that serve to guide behavior when it involves multiple steps. Links between object and action, in the present study, is decided by task repeating or switching. According to Humphreys and Riddoch (2000), object selection and action selection processes will constantly be updated over time. The determinant factors of the response blocking are; (i) longer-lasting representations of object-action association, object-action assemblies; (ii) shorter representations than object-action assemblies, reconfiguration of a task-set which are links object and action. In other words, the inhibition of the distractor blocked the action selection evoked temporally by the target stimulus after the object selection.

Our study also leads to a further understanding regarding the task switching cost. In previous studies, it has been considered that switching from one task-set to the other task-set in inter-trial using cueing and alternating paradigm (Meiran, 1996; Rogers & Monsell, 1995). But then the task switching is investigated by comparing task repeating block to task changing block (Allport, Styles, & Hsieh, 1994). However, even when our participants switched two tasks between the direction task and the location task, the task switching cost did not occur in the direction task. In spite of the absence of the switching cost in the direction task, the task switching influenced on the response blocking. The present study suggests that a task set contains not only an instruction task set in inter-trial but also the presence of the task switching context in inter-experiment. In the present study, the link between object and action as mentioned earlier may be confined to the presence of the task-set context.

Conclusion

The findings of this study lead to the following conclusions regarding object and action selection. (i) The response blocking effect observed by healthy participants. (ii) This effect of them is dependent on task switching. (iii) A task-set may consist of an instruction task-set and a task-set associated with the presence of the task switching context. These results suggest that the stimulus-response association decide the object and action selection, when task switches or repeats in a variety of the environments.

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