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Task-irrelevant factors influencing the selection of objects and actions

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We investigated task-irrelevant factors influencing the selection of objects and responses associated with the objects during visual search. We focused on response consistency effect and non-spatial stimulus-response compatibility, which based on the inhibition of an irrelevant distractor. Participants were asked to identify the color of the odd-one target among distractors using the arrow stimuli. To test for the response consistency effect, the stimulus displays consisted of either consistent or inconsistent stimuli in the direction of the arrow between the target and the distractors. The task responses were also either compatible or incompatible with the direction of the target arrow. These two effects were not related to the color dimension to be selected for the participants' responses. However, the two effects affected the reaction times for the identification of the target color. In particular, the response consistency effect varied depending on the conflict between the target and distractor concerning the reported attribute of the target. Furthermore, the response consistency effect did not interact with stimulus-response compatibility. These results showed that the response activation evoked by the distractors may interfere with the responses to the target in the feature selection level. And the consistency effect and the compatibility effect arise in the different level. The response activation may differ from that automatically evoked by the target to that evoked by responding to the target.

Keywords: visual search, object selection, action selection, task-relevance.

Introduction

In any environment there are a variety of objects that can be selected, and a variety of actions that are associated with and can be performed with these objects. The object selected may depend on visual task of the participant. The action selected may be a function of the responses evoked by the stimulus and assignments to responses (e.g., Cohen & Magen, 1999; Tucker & Elis, 1998).

In terms of object selection and action selection, Eriksen and Eriksen (1974) showed that failure to attend selectively to target objects has been observed in tasks such as the flanker task where distractors containing task-irrelevant information (see also, LaBerge & Brown, 1986; Miller, 1991). A target and distractors were presented on a display and participants discriminated the target by two categories of response. For example, participants may be presented with a row of letters and asked to concentrate attention on the target letter (e.g., H) in the centre and to ignore the simultaneously presented flanker (distractor) letters (e.g., S). Reaction times (RTs) are typically faster when the display contains distractors with consistent responses to the target (e.g., HHH), relative to when the display contains distractors with inconsistent responses to the target (e.g., SHS). When the distractor is not associated with the responses, RTs in baseline condition were obtained. We call this effect as response consistency effect in the present study.

Theeuwes (1996) introduced aspects of the flanker task in types of visual search tasks. Participants always searched for a target among distractors. In most visual search experiments, only a target present/absent response is required, and the identity of the distractors bears no relation to the present/absent response. However, as we stated earlier, the distractors can be associated to the response required by task. So, he added flanker tasks to the usual visual search. Like flanker tasks, the target always one of two letters that each required a different response, and distractor could be associated with the same response, a different response, or with no response at all. Even in visual search, RTs were faster when a display contained distractors with consistent responses to the target than when the display contained distractors with inconsistent responses to the target.

In the present study, we explore the task-irrelevant factors influencing the selection of objects and actions associated with the objects during visual search. We focused on the response consistency effect and the non-spatial stimulus-response compatibility effect. When participants' task is the identification of the target color, the consistency of the target shape and the compatibility between the target shape and –associated response are task-irrelevant factors. The former is used to examine the selection of objects and actions like flanker task. The latter is used to examine the action evoked by the objects. The non-spatial stimulus-response compatibility effect occurs even when task-relevant stimulus attribute is color (Simon, 1969). RTs are typically faster when the stimulus was compatible with responses, relative to when the stimulus was incompatible with responses. This effect is explained by the response activation evoked by the target shape (e.g., Michaels, 1988). We predict that two effects could be observed in the present study.

Experiment 1

Method

Participants. Twelve volunteers who had normal or corrected-to-normal vision and color vision participated in the study.

Apparatus. Stimuli were displayed at the centre of a 22-inch color monitor (MITSUBISHI Diamondotron FlatRDF22P II) controlled by an AV-tachistoscope system (IS-702, Iwatsu ISEL Co. Ltd.). RTs were measured by means of a digital millisecond timer from the onset of the target stimuli to the participants' response by pressing a key. RT and accuracy were recorded.

Stimuli. Examples of stimuli are shown in Figure 1. A trial consisted of three successive displays: fixation, blank, and search display (see Figure 1). The fixation consisted of a small white cross (0.2˚ in diameter) presented at the centre of the display. The search display consisted of eight arrows (0.7˚ x 1.5˚, high x wide). These arrows were located on an imaginary circle drawn around the centre of the display with a radius of 5˚. On each trial, the target arrow was red, and the others were green as distractors. Or, the green target and the red distractors were presented. The luminance of the stimuli for the white dot was 41 cd/m^2, for the red dot was 27 cd/m^2, and for the green dot was 22 cd/m^2.

Procedure. The experiment was conducted in a semi-dark room. Participants viewed the monitor from a distance of 57cm. Each trial began with the presentation of the fixation for 1000 ms. Participants were instructed to fix their eyes on the fixation when it appeared and to maintain that eye fixation. This was followed by a blank screen for 500 ms. Next, the search display was presented until the participants' responses. On the search display, when the target color was red, while the distractor color was green. when the target color was green, while the distractor color was red. The target color changed red or green in every trial. The participant's task was to respond the color of the target among distractors. Key assignment was counterbalanced between blocks. Participants were required to respond as quickly as possible while attempting to minimize errors. Responses to the task display were made by pressing one of two keys assigned to each index finger of the participant's both hands. After the participant's response, the blank screen was shown for 1000 ms followed by the fixation display of the next trial. RTs to the search display were measured. We were interested in comparing reaction times for the inconsistent displays (one target arrow and seven distractor arrows pointing in opposite directions) and the consistent displays (one target arrow and seven distractor arrows pointing in same directions). For example, in the inconsistent condition, one arrow and seven opposite direction arrows were presented. Whether the target was inconsistent or consistent with the distractor may affect the response to the target. We also examined the effects of spatial compatibility between the direction (left or right) of the stimulus and the response (left or right button press). For example, in the incompatible condition, left arrow was responded by the right key. Within-block factors were target-distractor consistency (consistent vs. inconsistent) and stimulus-response compatibility (compatible vs. incompatible).

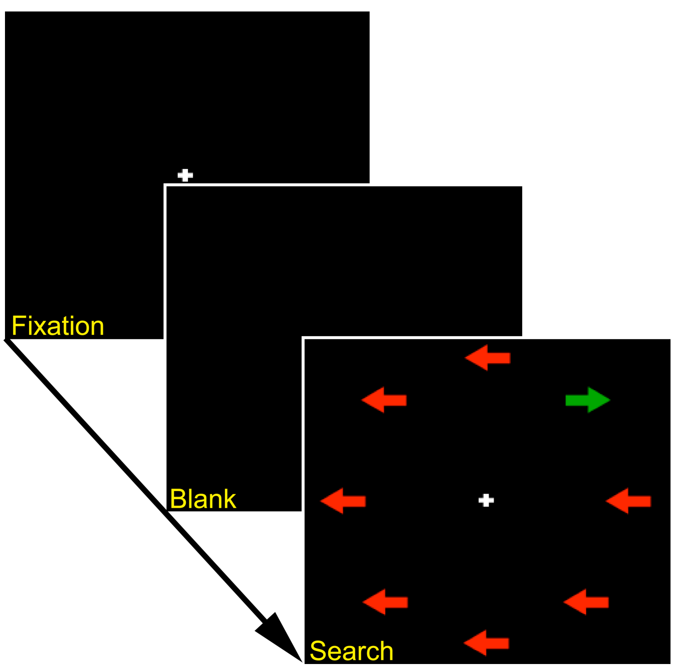

Figure 1. The display sequence of stimuli in Experiment 1.

An experimental block consisted of 128 trials. Four conditions, which consisted of consistency (consistent vs. inconsistent) x compatibility (compatible vs. incompatible) appeared for an equal number of trials (32 trials) in each block. There were sixteen stimulus patterns in the task display. 64 patterns consist of consistency (consistent vs. inconsistent) x compatibility (compatible vs. incompatible) x target color (red vs. green) x target position (eight positions). Participants were tested individually for a practice block (16-32 trials) and four experimental blocks. Two experimental blocks were assigned right/left key to the red/green target, the other two experimental blocks were assigned right/left key to the green/red target.

Results

One participant with error rates of over 10% were excluded from the data set as outliers. Figure 2 shows the mean correct RTs for Experiment 1. RTs for the consistent condition was slower than those for the inconsistent condition. Furthermore, RTs for the incompatible condition was slower than those for the compatible condition. The data were analyzed by a two-way ANOVA, with consistency and compatibility as the main terms. Both main effects were significant; consistency, $F(1, 10) = 22.35$, $p < .001$ and compatibility, $F(1, 10) = 6.79$, $p < .03$. The

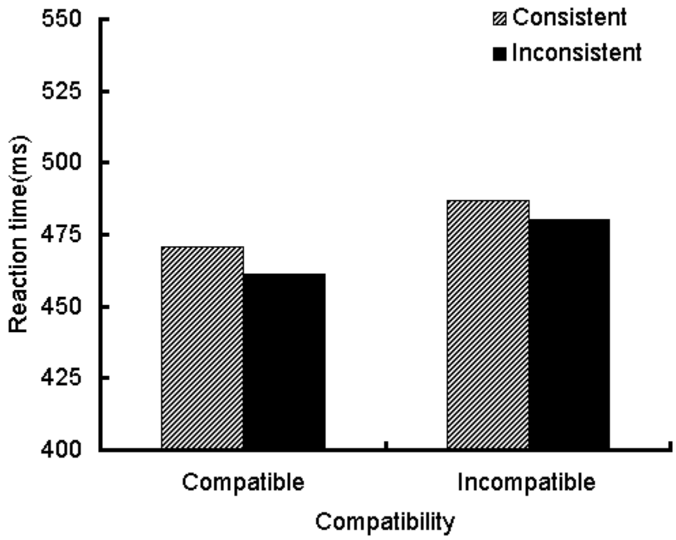

Figure 2. RTs for consistent and in consistent conditions used in Experiment 1, shown for each compatibility condition.

consistency x compatibility interaction was not significant (p =.77).

The mean error rates to the target are shown in the upper Table 1. The error rates were analyzed by a two-way ANOVA with consistency and compatibility as the main terms did not show significant main effects or interactions, suggesting there was no speed-accuracy tradeoff.

Discussion

RTs for the consistent condition were slower than those for the inconsistent condition, that is, the reverse consistency effect occurred. This result did not replicate the previous studies such as the phenomena observed by flanker task (e.g., Eriksen & Eriksen, 1974). Furthermore, RTs for the incompatible condition was slower than those for the compatible condition. So, the compatibility effect was observed.

The reverse consistency effect suggests that the response activation evoked by the distractors interfered with the responses to the target. When the target arrow and the distractor arrows are the same directions in the consistent condition, participants have to ignore some task-irrelevant attributes of distractors defined by the task-relevant color. We could consider two factors as these attribute to be inhibited. First, it is the arrow direction of the distractor. The arrow stimuli might cause response activation evoked by the distractors. For example, when the right arrows of distrators were presented, "right " response activation would reduce, while when the right arrow of target was presented, "right " response activation would gain. Thus, RTs for the consistent condition delayed. Second, the color of target was always the different color from the distractors color. The distractors color might conflict with target color in the feature dimension level. However, it is unclear whether this conflict arises from the color dimension

Table 1. Percentage of Errors (in parentheses) on Search Displays in Experiments 1 and 2.

	Compatibility	
	Compatible	Incompatible
Experiment 1		
Consistent	4.0	3.1
Inconsistent	5.4	4.5
Experiment 2		
Consistent	3.6	2.6
Inconsistent	4.0	2.7

assigned to responses, or the color dimension of the reported attributes. If the former affected the consistency effect more than the latter, some sort of effects concerning the consistency effect would have interacted or interact with the stimulus-response compatibility.

Experiment 2

In Experiment 2, we manipulated the distractors color. We changed the distractors color from the opposed to the target color, to gray color. So, the color of the distractors might not conflict with that of the target. If the consistency effect occurred, the reverse consistency effect in Experiment 1 would be caused by the balance competing color for the reported attribute to the target and distractors.

Method

Participants. Twelve volunteers who had normal or corrected-to-normal vision and color vision participated in the study.

Apparatus, Stimuli, and Procedure. Apparatus and procedure were the same as those in Experiment 1. Except that stimuli on the search display, that is, the distractors were always gray color. The target color changed red or green in every trial like Experiment 1. The luminance of the stimuli for the gray dot was 17 cd/m^2.

Results

One participant with error rates of over 10% were excluded from the data set as outliers. Figure 3 shows the mean correct RTs for Experiment 2. RTs for the inconsistent condition were slower than those for the consistent condition. Furthermore, RTs for the incompatible condition was slower than those for the compatible condition. The data were analyzed by a two-way ANOVA, with consistency and compatibility as the main terms. Both main effects were significant; consistency, $F(1, 10) = 5{,}32$, $p < .05$ and compatibility, $F(1, 10) = 10.73$, $p < .01$. The consistency x compatibility interaction was not significant, (p =.14).

The mean error rates to the target are shown in the lower of Table 1. The error rates were analyzed by a two-way

ANOVA with consistency and compatibility as the main terms did not show significant main effects or interactions, suggesting there was no speed-accuracy tradeoff.

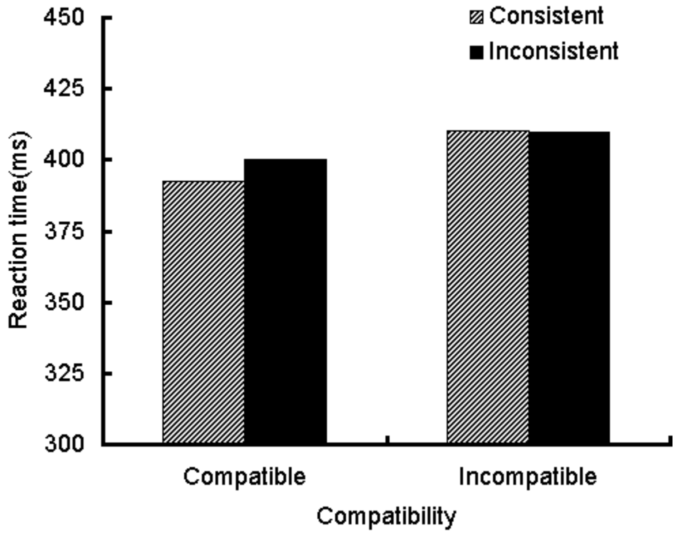

Figure 3. RTs for consistent and in consistent conditions used in Experiment 2, shown for each compatibility condition.

General Discussion

The present studies suggest two points as follows. First, in Experiment 1, the reverse consistency effect occurred. On the other hand, in Experiment 2, the consistency effect occurred. These results indicate that the reverse consistency effect was caused by the balance competing color for the reported attribute to the target and distractors. Because the reported attribute to the colored target was always the different color from the distractor color in Experiment 1, the distractor target might conflict with target color in the feature dimension level. The response activation evoked by the color of distractors may interfere with the responses to the target in the feature selection level.

Second, in both Experiments 1 and 2, the compatibility effect also was observed. Furthermore, the compatibility effect did not interact with the consistency effect. These results showed that the consistency effect and the compatibility effect arose in the different level. The response activation may differ from that automatically evoked by the target, to that evoked by responses to the target. The former activation is concerned with the consistency effect. This response activation might result from the some perceptual or task-relevant attributes. That is the reported attributes. In contrast, the latter activation is concerned with the compatibility effect. This response activation might result from the response assignment or responding actually to the target shape, the arrow direction in this study. In speculation, in the level in which the consistency effect occurred, the attributes of the distractors would be inhibited based on the task-relevant color dimension, that is relatively early selection level. This level may be followed by the level, in which the compatibility effect occurred by the key press, that is late selection level.

Conclusion

We conclude that task-irrelevant factors influenced on the selection of objects and actions. The response activation evoked by the color of distractors may interfere with the responses to the target in the feature selection level. Two types of response activations undertake jointly in the different level.

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