Does the Cue's Feature Matter?

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To find out the level of processing of pre-attentive objects we preferred to use cues, i.e., a transient visual stimuli that may attract attention automatically or voluntarily (peripherally or centrally presented cues). In one of our recent experiments (Authors, Unpublished experiment), we observed that color similarity of cue and target does not improve subject's performance in a peripherally cued detection task. In this paper we describe another experiment which had two kinds of symbolic cues presented in the fixation point (at the center) and showed the subjects where to deploy their attention (right or left) according to their shapes. Subjects were asked to detect the target (i.e. a simple detection task) or to discriminate between two alternate targets, different in some features except color (i.e. a common discrimination task). We compared the reaction time (RT) in both types in same feature condition (target's color was similar to cue's) and different feature condition (target's color was different from cue's). Results showed significant difference between them. So we concluded that with increased exposure, color -as an unattended feature of the central cue- can also get processed and improve subjects performance.

Even while our eyes are fixated on a particular location, it does not appear that the visual system passively processes all the information available within the image. Rather, we selectively attend to different aspects of it at different times. Sometimes we attend globally to the whole scene; at other times we attend to a selected object or set of objects; at still other times we attend locally to a specific object part. We may even concentrate on a particular property of a particular object, such as color.

Our ability to engage in these flexible strategies for processing different information within the visual field is generally referred to as "attention" which is an important component of vision.

Complex visual scenes like the ones that we normally look at contain a great amount of information, far more than we can be aware of at one time. As a result, attention is required to allocate the limited capacity in vision to spatial locations and select the stimuli that are further processed (Lavie & Tsal, 1994). In other words, attention enables an organism to focus the bulk of its visual processing capacity on objects, locations and properties of interest but on the other hand unattended objects and properties receive correspondingly less processing. The benefits and costs of selective attention had been studied most extensively by Posner and his colleagues (1980) which led to developing the attentional cuing paradigm. Cue is a transient visual stimulus that may attract attention automatically or voluntarily which is named a peripheral and a central cue respectively. It is obvious that a cue, an-arrow for instance- which is presented in the centre of the visual field, is a central cue.

It is now evident that prior information concerning the spatial location of a subsequent target facilitates the selection of that target for further visual processing (Eriksen & Hoffman, 1973; Jonides, 1981; Posner, 1980). But the effect of prior information about object features such as color, shape and orientation has been the subject of much controversy over the last couple of decades. Many studies have been done to compare spatial and feature-based visual attention and some researchers argue that stimulus selection via spatial location is primary (van der Heijden, 1993; Johnston & Pashler, 1990; Schneider, 1995; Tsal & Lavie, 1988, 1993), whereas others argue that location is just one selection attribute among many, including object features such as color, shape and orientation (Bundesen, 1990; Duncan, 1981; Humphreys, 1981; Laarni, 1999; Laarni et al., 1996)

In most of the experiments comparing location and color cues, color processing was necessary for target identification so the subjects had to shift their attention to the color of the cue but in this study experiments were designed in such a way that the color of the cues attracts attention as least as possible. As a result we could find out what happens in the absence of attention.

In one of our recent studies (Authors, Unpublished experiment) we used peripheral cues in a detection task and compared subjects' results when the color of the cue was similar to or different from the target's. We observed no significant difference between these two conditions and reasoned that because the color cue was actually uninformative and as it was a detection task, there was no need of processing the color of the cues but other reasons are also possible; hence, in the present experiment we used central cues and we altered the time courses. The difference between these two conditions will be discussed in more details later part, but we could just assure you that we still tried to keep color as an unattended feature of the cue to find out the level of processing of information in the absence of attention. In other words, our goal was to show the possible association between color and subjects' performance.

Method

Subjects

Eight subjects participated in this experiment (4 females and 4 males). Subjects' ages ranged from 18 to 21 years. All of them were right handed and had normal or corrected to normal vision. They took part in our experiment voluntarily and they were not aware of the purpose of our experiment.

Apparatus

The stimuli were presented on a 14" LCD

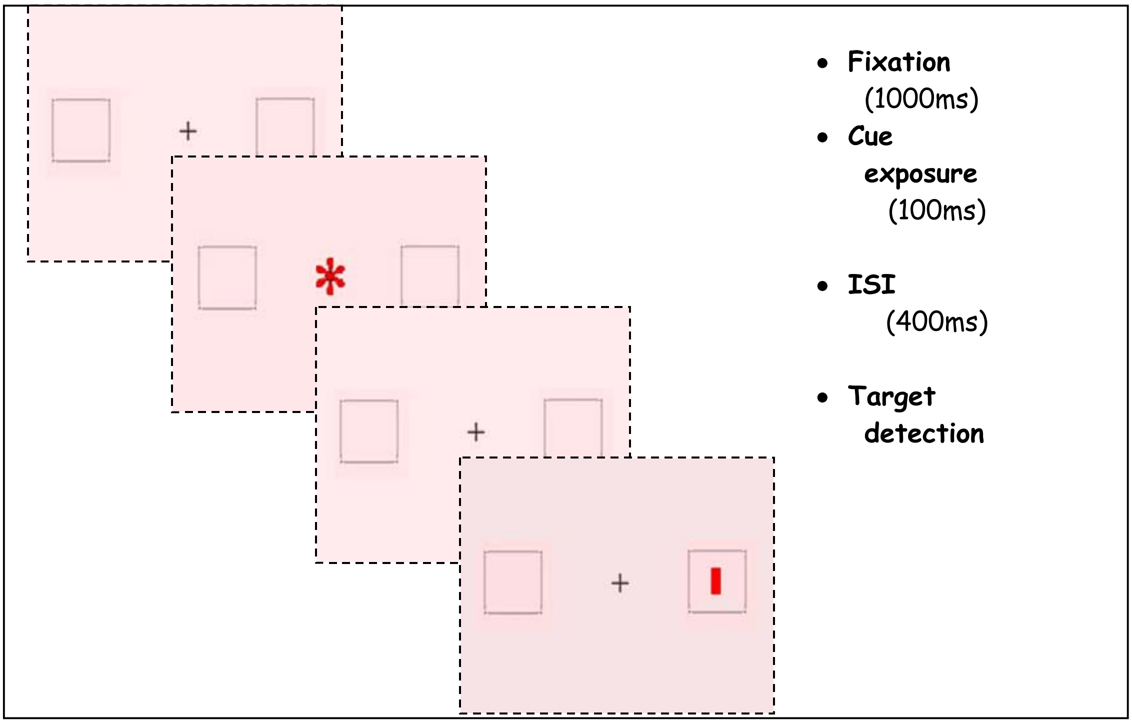

Figure 1.
Experimental trial sequence; the cue can be either an asterisk or a circle, and all through the trial, target's location was limited by two gray squares (colors and sizes are schematic)

monitor. C++ builder software was used to control the experiment and record the responses.

Task and stimuli

In each block, which had 100 trials, subjects had to gaze at the fixation point and maintain this fixation throughout the trial. The first display (fixation) lasted for 1000 ms. In the second display a symbolic cue appeared on the centre of the screen which was either a circle or an asterisk. These symbolic cues showed to subjects were to deploy their attention. They were taught that an asterisk meant right and a circle meant left, i.e., following an asterisk the target appeared on the right side of the visual field and after a circle the target appeared on the left side (Figure 1).

Of course in only 80% of the trials the cue was valid. In 20% of the trials when the cue was an asterisk, for instance, target appeared on the left side of the visual field (invalid trial). Different types of trials were randomly intermixed. Cues and targets could have different colors (green or red) but the color was of no importance for the subjects; in other words, it was uninformative for them. The cue lasted 100 ms. Then there was an interval of 400 ms (this is called ISI that is the abbreviation for Inter Stimulus Interval) and at last the target appeared. Subjects were asked either to press a key as soon they detect the target or to discriminate whether the target was horizontal or vertical and press two different keys. They were given a feedback when a response was made.

In the detection task the target was always a vertical bar which could be red or green and subjects were asked to press the space key with their right hand as soon as they detect the target.

In the other type, we ran a common discrimination task. Subjects were asked to attend to the symbolic cue and wait for the target appearance. This time subjects were asked to discriminate whether the target was horizontal or vertical and press two different keys (“Z” – “/”) with their left and right hands.

In 10% of the trials in a detection task, the target didn’t appear (catch trial) and if a subject pressed the key in those catch trials, his results would have been excluded from the analysis. Trials in which the response was made before 100ms or after 1000ms were also excluded from the analysis.

Error trials in a discrimination task included trials in which the subjects pressed the wrong key or if his reaction time was shorter than 150ms or longer than 2000ms.

We have selected the above timing characteristics upon our previous experiences and pilots, as well as findings about temporal properties of attention and sensory pathways reported in the literature (Sears & Pylyshyn, 2000).

In the same setting, exposure times of cues and ISIs could have been altered as variables that are shown in Table 1. We used empirical timings to have a gross assessment of the behavior when manipulated in temporal dimension, and we found it interesting for reporting preliminarily in this publication.

Results and Discussion

The mean response times of detection and discrimination tasks in trials with either asterisk or circles as their central cues are presented in Figure 2[A], and [B], respectively. Data were analyzed with paired t-test and alphas under 0.05 were accepted as significant. There was a significant difference between mean reaction times in valid and invalid trials which is shown in Figure 2 [B]. This “cue validity effect” was also seen in detection tasks (but it is not shown in Figure 2 [A]).

As it is evident, there was a significant difference between “same feature” and “different feature” conditions. In the same feature condition the color of the target was identical to the cue’s, but in the different feature condition was not. This shows us that even when the color of the cue is uninformative it will get processed and more importantly the effect of color was seen in a detection task in which processing the color of the cue or target was not necessary to perform the task.

Table 1.
Examples of time of Cues and ISIs, which were selected in the modified study, in millisecond

Test	A	B	C	D	E	F	G	H	I	J
Cue	200	300	400	200	100	150	100	200	100	100
ISI	1300	1200	1100	700	400	400	450	300	300	500

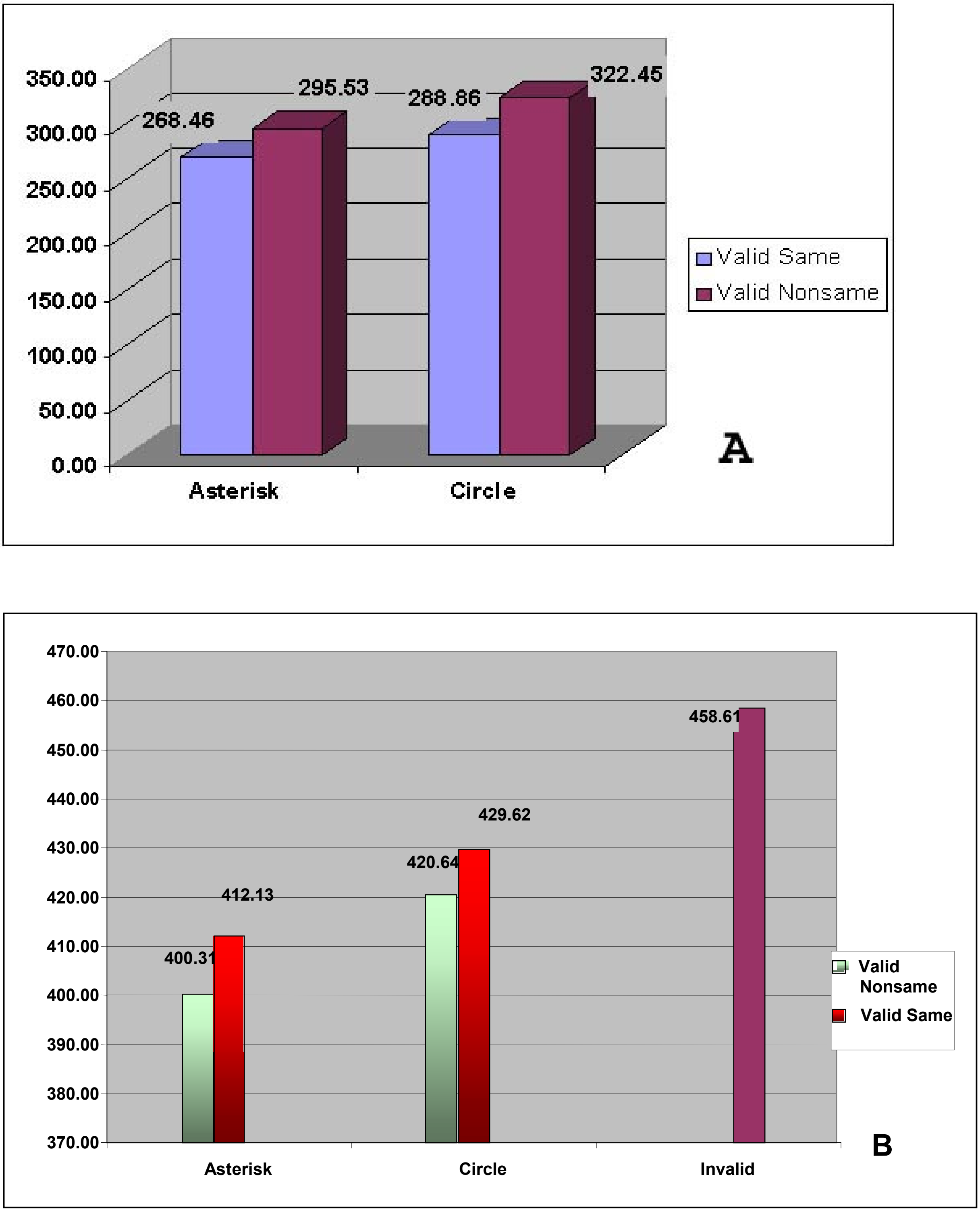

Figure 2.
Comparison of 'same feature' and 'different feature' conditions in both detection [A] and discrimination [B] tasks. As shown in [B], invalid cue RTs were still greater than valid ones.

As we mentioned above we analyzed trials with asterisk or circle separately because they may be different in processing. For instance it is obvious that shifting attention to right side of the visual field takes less time for most people (Vandenberghe, 2000) which is compatible with what you see in the chart; because the mean reaction time for trials with asterisks is longer than trials with circles.

If you compare Figure 2 [A] and [B] you will discover that the average of the reaction times is longer in a discrimination task, because it takes more time to discriminate whether a bar is vertical or horizontal than just detecting its presence.

In Figure 2 [B] the significant difference between valid and invalid trials assures us that subjects would certainly use the cue to shift their attention before the presence of target but the difference between same feature and different feature conditions shows us that the subjects could also process color even if it is an unattended feature of the cue. But how could we call it an unattended feature when it is a discrimination task? Firstly, we should say that although it is a discrimination task there is still no need of processing the color of the cue to discriminate whether the bar is horizontal or vertical and perform the task. Secondly, color cue was uninformative thus; it was of no importance for the system to process color of the cue because it was not useful.

Now let's go back to our previous study (Authors, Unpublished experiment) in which no color effect was observed when we used a peripheral cue in a detection task. As we mentioned earlier in the introduction section, this result could suggest that under such circumstances, cue's color may not get processed. In other words it suggests that other cue's features such as color may not get processed and the only thing which is important for the system is cue's location and not its nature; or more likely, cue processing does not reach the level that affects subject's performance or at least it was not obvious in the kind of respond that we observed (target detection). But what was the difference between that experiment and our present experiment? The answer lies in the kind of cue that was applied. Peripheral and central cues are different not only in their processing but also in their time course. Concerning their processing it seems that peripheral cues attract attention automatically but as for the central cues, most of the time you should deploy your attention to the cued location voluntarily. Concerning their timing we should say that cue exposure and ISI were longer for the central cues but as it is shown in Table 1 we altered the SOAs (Stimulus Onset Asynchrony) and discovered that color effect was not seen in shorter exposure times (Figure 3). Where is the threshold ? how it can differ in case of features other than color? this can be our prospectus for next works to find the fine responses.

As a result we can conclude that with increased exposure color which is actually an unattended feature can also get processed and improve subject's performance. Our findings are in agreement with previous studies which demonstrated that selection

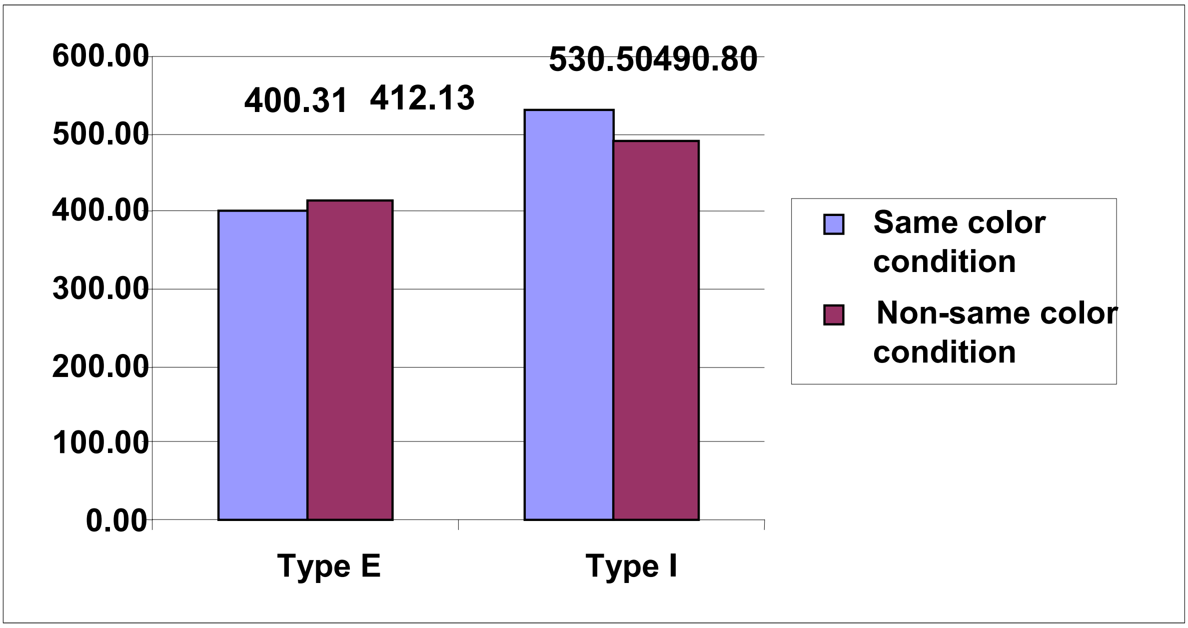

Figure 3.
Comparison of mean reaction times of valid trials in a discrimination task with asterisk cues.

by location is faster or occurs earlier than selection by object features (Tanaka & Shimojo, 1996; Pisella et al., 1998). ERP indices of visual attention are also consistent with faster and earlier processing of location cues (Mangun, 1990).

Our results only suggest that by gradually increasing the exposure times, color –an unattended feature of the object- can also get processed but the exact mechanisms which underlie this fact have to be elucidated further which can be a launch for future investigation in this regard.

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