GROUPING BY CONFIGURATION INFLUENCES SEARCH

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Abstract

Grouping by configuration was studied in two experiments using a visual search paradigm (conjunction and preview search). We used two kinds of grouping: orientation (Exp 1) and texture grouping (Exp 2) and there were two kinds of configuration (regular and irregular). Regular configurations facilitated search compared to irregular configurations (Exp 1 and 2). Grouping by orientation was influential in preview search (Exp 1) and grouping by texture had an effect on conjunction search (Exp 2). The role of configuration based on different dimensions in search is discussed.

The interaction between perceptual grouping and visual search has been extensively studied. Treisman (1982) and Robertson et al. (2003) looked at the effect on search performance of grouping homogeneous items into square or rectangular matrices. Participants were reliably faster when the display was grouped than when the items were scattered randomly. Kingstone et al. (1999) looked at grouping by motion on search. Target and non-targets were presented on two different diagonals and oscillated in, or out, of phase. When the non-targets moved in phase it was easier to reject them and search efficiently. The preview paradigm (where some distracters are presented earlier than the remainder) has also been used to investigate grouping processes in search (Kunar, Humphreys, Smith, and Hulleman, 2003). Preview search allows grouped distracters to be separated in time from the remaining search items, so the nature and time course of the grouping effect can be assessed. Search was disrupted when the configuration changed identity on the arrival of the remaining search items (Kunar et al, 2003). Location changes of the whole configuration did not alter performance, provided the relative positions of the items in the configuration were held constant. Kunar et al (2003) concluded that configural coding facilitates search since it allowed old distractors in the preview to be rejected as a group. These studies together make important points about visual attention. Firstly, attention does not necessarily proceed on item by item basis. Stimuli can be grouped and the resulting groups can become the objects of attention. Secondly, rejecting non-targets is easier when they are grouped than when they are randomly distributed.

We looked at the effect of configural grouping (regular and irregular) on conjunction and preview search. We also manipulated how these configurations were grouped. Experiment 1 tested grouping by orientation (identical global and local orientations). Experiment 2 tested grouping by texture (all the distracters had thin lines). A location change manipulation was also incorporated, following Kunar et al. (2003), to see if the regular configurations survive location changes better than the irregular configurations.

Method

The distracters were horizontal and vertical black ellipses containing a white line with the same orientation as the ellipse, e.g., a thick or thin vertical line in a vertical ellipse (Figure 1). The stimuli measured 1.24º x 0.76º (viewing distance = 60cm), presented on a gray background. The target was always an item where the orientations of the line and the ellipse

were mismatched. In these experiments, the target was a horizontal ellipse with a vertical line. The line in the target could be either thick (p=0.5) or thin and was present on all trials.

A set of possible configurations were created and ratings were obtained from ten independent raters. Each rater rated the displays on a scale ranging from 1 to 7, 1 indicating irregular and 7 indicating regular and the intermediate values indicating a tendency either towards regularity or irregularity. Frequency tables were prepared and 6 regular and 6 irregular configurations were chosen for each display size (we used two display sizes of 10 and 16) from a set of 10 in each category. Regular configurations tended to conform to standard shapes such as square or triangle (see Figure 1).

Participants

40 participants (20 in each experiment) took part in the study for course credits. All were students of University of Birmingham in the age range of 18-28 years (mean age: 20 years). All had normal or corrected to normal vision.

Procedure

Participants completed three conditions presented in separate blocks: (i) the conjunction baseline, (ii) preview search, and (iii) location-change preview search. A fixation cross appeared at the beginning of all trials (500ms). In condition (i) this was immediately followed by the search display. Participants were instructed to search for the target immediately after the items appeared. In the preview condition (ii), one set of distracters appeared first for 1000ms (the preview), followed by the target and search distracters in the subsequent search display (see Figure 2). Participants were instructed to fixate and ignore the preview items until the search items appeared and to search for the target only when the second set of items appeared. Condition (iii) was the same as condition (ii) except that the preview items moved up or down by 15 pixels when the search items and the target were added. The search items remained on the screen until response in all the conditions.

Participants pressed "Z" on the keyboard if the line in the target was thick and "M" if it was thin. The subsequent trial started after an inter-trial interval of 500ms. All participants completed 24 practice trials for all the three conditions before the main experiment started. The three conditions were administered in a counterbalanced order for all the participants. There were 288 trials in total administered in 6 blocks (2 blocks for each search condition).
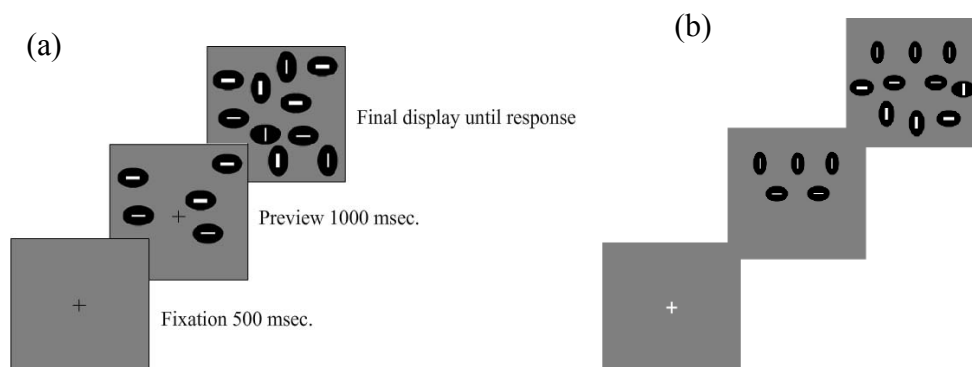

Figure 1. Illustrations of stimuli and display sequence in experiment 1 (a) and experiment 2 (b). (b) Also shows an example of a regular configuration

Results

Incorrect trials were dropped from the analysis (3.4%). Reaction times (RTs) greater than two standard deviations away from the mean and RTs less than 200ms were excluded from the analysis. Repeated measures analyses of variance (ANOVA) were carried out with the following variables: display size (10, 16), condition (conjunction, preview and location-change preview), and configuration (regular and irregular).

Experiment 1

RTs increased as display size increased [F (1,19)=86.210, $p<0.001$]. RTs for trials with regular configurations were faster than those for trials with irregular configurations [F(1,19)=18.449, $p<0.01$]. Finally condition was also significant [F(2,38)=16.235, $p<0.01$]. Preview RTs were faster compared to conjunction and location-change preview RTs.

All of the two way interactions were significant. The data showed more effect of configuration for the bigger display size [F(1,19)=7.312, $p<0.05$]. Configuration*condition was significant [F(2,38)=5.450, $p<0.01$]. Configuration affected RTs in both the preview conditions, but not in the conjunction search condition. Display size*condition was significant [F(2,38)=4.531, $p<0.05$]. There were no reliable three way interactions [F(2,38)=1.097, $p=0.344$]. Separate ANOVAs for each condition were carried out to understand the interaction effects observed above. The effect of display size was significant in all the conditions (conjunction [F(1,19)=46.714, p<0.01]; preview [F(1,19)=49.047, p<0.01]; location-change preview [F(1,19)=46.449, p<0.01]) , but regular configurations facilitated search only in the two preview conditions (conjunction [F(1,19)=2.418, p=0.136]; preview [F(1,19)=5.956, p<0.05]; location-change preview [F(1,19)=25.340, p<0.01])
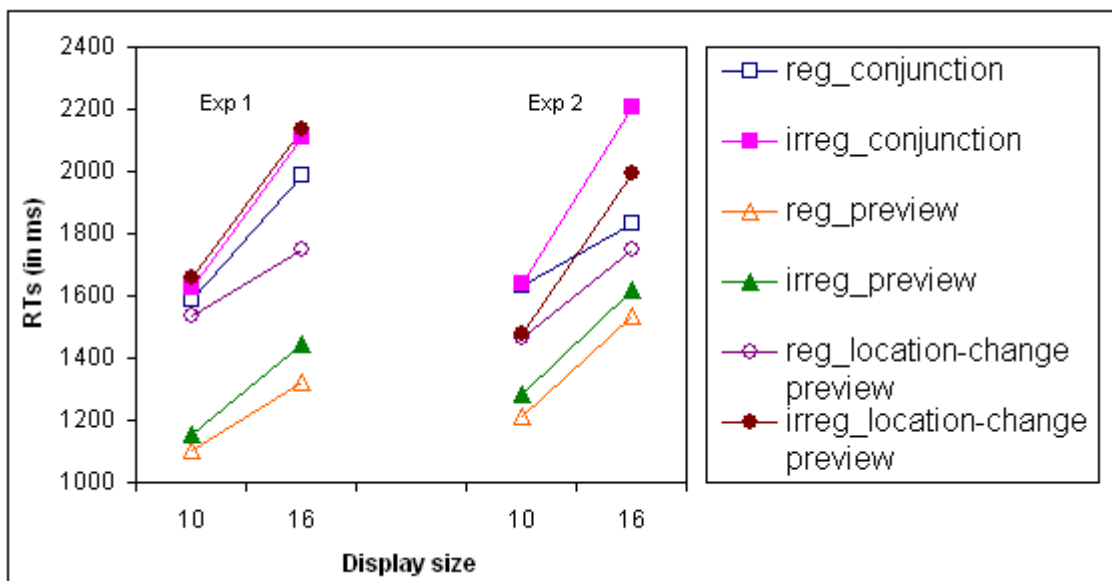

Figure 2. Reaction times for Exp 1 (group by orientation) and Exp 2 (group by texture)

Experiment 2

Participants responded faster for the smaller display size than for larger display size [F(1,19)=158.675, p<0.01]. RTs were again faster for regular configurations compared to irregular configurations (F(1,19)=19.653, p<0.01). Preview RTs were faster compared to conjunction and location-change preview RTs [F(2,38)=10.072, p<0.01].

There was a significant interaction between display size and configuration [$F_{(1,19)}$=11.790, p<0.01]. The three way interactions also significant [$F_{(2,38)}$=4.178, p<0.05]. Other interactions were not statistically significant (Fs<1). Separate ANOVAs were carried out on each condition to understand the three way interactions. They revealed an effect of display size in all the conditions (conjunction [$F_{(1,19)}$=41.517, p<0.01]; preview [$F_{(1,19)}$=56.259, p<0.01]; location-change preview [$F_{(1,19)}$=64.408, p<0.01]). Regular configurations facilitated RTs in conjunction and location-change preview conditions, but not in the preview condition (conjunction [$F_{(1,19)}$=5.615, p<0.05]; preview [$F_{(1,19)}$=3.058, p=0.09]; location-change preview [$F_{(1,19)}$=4.274, p=0.05])

Discussion

Our results seem to show that the benefit from configuration is sensitive to the nature of the grouping cue. When configurations were grouped by the global and local orientations of the items (Exp 1) the preview conditions benefited whereas conjunction search did not. This suggests that temporal and spatial grouping based on shape information in the initial configurations is facilitatory, perhaps enabling distractors in a regular configuration to be rejected together. This held even when the configuration shifted its location in the field, similar to Kunar et al., (2003). In contrast, when the same configurations were grouped by local width (Exp 2), regular configurations reliably reduced the RTs in conjunction search and the configuration change condition, but not when the configuration in the preview stayed the same. This second kind of grouping (by local width) may have given rise to some sort of texture grouping which helped to reject those items successfully in conjunction search. This was also be effective in the preview change condition. One account of these data is that texture based grouping, and the rejection of items having a different texture, is effective when all of the search stimuli are represented together, when a density change in the display may be used to guide attention. However, when the items remain in the same location (under standard preview conditions), they may be coded in terms of their locations but not their texture, and participants are then less sensitive to the texture difference between these items and the other stimuli in the displays.

The current studies suggest that configural coding plays a strong role in search, but that its role varies according to the way the configuration is formed (based on global orientation vs. surface texture). Presenting stimuli in a preview may increase the effect of coding stimuli as a shape configuration and rejecting them together, but it may decrease effects of segmenting displays based on texture differences between elements. The inter-play between the configural coding of shape and texture, and the interactions between these factors and temporal segmentation (in preview search) are important issues for future research.

References

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