The Effects of Visual Similarity on the Type of Processing Used in a Visual Search Task

This study investigated whether the type of processing used in a visual search task depends on such characteristics as the physical similarity between the sought-after item (the 'target') and the other items in a display (the 'distractors'). There are many reports that visual search is much easier when a target is distinctively different from the distractors (e.g., Treisman, 1984). For example, Treisman found that people searching for a red target in a display of green distractors did not take any longer to find the target when the display contained 24 items than they did when it contained 2 items. **[statement of general hypothesis, relevant evidence]**

However, in Treisman's task, participants knew in advance what the relevant characteristic of the target was. Thus, one might imagine that they could preset a 'perceptual filter' to respond only to the presence of red, in this example, and they would not have to actually examine the display to know which item was red.

In the present study, participants did not know what the relevant feature was until the display was presented. Thus, the critical question was whether or not they could switch between one or the other of two modes of processing. One type of processing is a controlled, serial search, in which it is assumed that the display is examined item-by-item. With this type of processing, the amount of time to respond would be expected to increase as the number of items in the display increased (e.g., Neisser, 1963). The other type of processing is an automatic, parallel search, in which it is assumed that the entire display is examined at once. With this type of processing, the amount of time to respond would be expected to be relatively independent of the number of items in the display. **[statement of how the current study differs from other research]**

To investigate whether processing depends on visual similarity, the participant was presented with two kinds of displays. In Similar displays, the target and the distractor items were visually similar. In Dissimilar displays, the target and the distractor items were visually dissimilar. To create similar and dissimilar displays, the letters 'N' and 'O' were used as target letters, and the letters 'M', 'V', 'W' , 'C', 'G', and 'Q' were used to create two sets of distractors. One set of materials ('N', 'M', 'V','W') had angled lines, and the other set ('O', 'C', 'G','Q') had curved lines. Thus, Similar displays involved searching for 'N' among angled distractors or searching for 'O' among curved distractors, whereas Dissimilar displays involved seaching for 'N' among curved distractors or searching for 'O' among angled distractors. **[statement of how the hypothesis will be examined]**

In order to distinguish between serial and parallel processing modes, the display size was varied between 2 and 16 items. The key question, then, was whether response time would depend on display size, and whether any effects of display size were different for Similar as compared to Dissimilar conditions. **[statement of what results will be informative]**

Method

Subjects. The participant was a 52-year old left-handed male with vision corrected to normal.
Materials. The stimulus materials were the capital letters 'N', 'M', 'V', 'W', 'O', 'C', 'G', and 'Q', displayed in a standard font on the screen of a PC-compatible computer.
Design. The study was designed as a 4 x 2 x 2 factorial within-subject design. The three factors were display size (2, 4, 8 and 16), Target-Distractor Similarity (Similar vs. Dissimilar) and

Target Presence (Present vs. Absent). There were 12 trials for each of the 16 cells generated by this design, for a total of 192 trials. Trials were presented in blocks of 32 tests, with a break between each block. The ordering of conditions was randomized, with the constraint that each cell occurred twice in a block of 32 tests.

Procedure. The participant sat comfortably in front of the computer. Prior to beginning the experimental trials, he was given some practice trials, which involved the same materials but were not scored. The participant selected the 'z' key to press for 'Yes' and the '/' to press for 'No'; thus he used his dominant hand for affirmative responses.

Each trial began with the display of the target letter for that trial in the center of the screen. When the participant was ready, he pressed the space bar, whereupon the target letter was replaced by a display of from 2 to 16 letters, which remained on the screen until a response was entered. When the participant responded the display was cleared, and feedback was provided about the accuracy of the response. The participant was asked to respond as quickly as possible without making errors.

Results

The data of interest are the mean correct reaction times for each cell of the factorial design. **[Statement of what data are analyzed]**. These data are summarized in Figure 1, which depicts response time as a function of display size. **[Reference to figure or table that summarizes data].** As can be seen in the figure, response times for the Similar condition showed fairly regular increases with display size. This was most apparent for the Target Absent trials, for which the response times increased from 722 ms at a Display Size of 2 to almost 1,500 ms for a Display Size of 16. Response times for the Dissimilar condition showed much lower increases with the size of the display. Of particular note, there was almost no change in response times between displays of 8 and displays of 16. **[Description of general features of data].**

The slopes of the functions shown in Figure 1 are consistent with this description. For the Similar condition, the slope for the Target Absent condition was 52.2 ms/item, whereas for the Dissimilar condition, the slope for the Target Absent condition was only 13.6 ms/item. These results indicate that displays were processed faster in the Dissimilar condition than in the Similar condition, but there does appear to be an effect of display size.

If one assumes that processing in the Similar condition was according to a controlled serial search, then it is possible to distinguish between a *self-terminating* and an *exhaustive* search by comparing the slopes of the functions for Target Present vs. Target Absent. As discussed by Sternberg (1966), the ratio of these slopes is a marker of the type of search, because a self-terminating search should produce differences in slope in about a 2:1 ratio, whereas an exhaustive search should produce slopes that are about 1:1.

These data clearly suggest that the participant used an exhaustive search, because of the closeness of the slope for Target Present (49.6 ms/item) and for Target Absent (52.2 ms/item).

Discussion

The goal of this study was to determine whether the type of processing used in a visual

scanning task might depend on the physical similarity between targets and distractors. The results of this study suggest that in fact the same processing was used in both Similar and Dissimilar conditions, but the speed of processing was faster in the latter.

The results of this study appear to differ from those reported by Treisman (1964). One key difference between this study and Treisman's is the within-subject nature of the present design. Presumably, it was not possible for the participant to preset a perceptual filter in the present case. Thus, it appears that there may be limited flexibility on the part of human observers to switching between one type of processing mode and another. **[statement of relation to prior literature, discussion of reasons for discrepancies.]**.