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Can Haptic Search be Parallel? Not When Using a Cross as a Target and Circles as Distractors.

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Abstract. Subjects performed a haptic search task closely resembling Treisman and Gelade's visual search paradigm [3]. They had to search for a cross amongst circles presented to their fingertips, and indicate either the circle's presence by lifting the corresponding finger, or its absence by lifting all fingers. Despite the fact that the target possessed a feature that was absent in the distractor, we found a serial search pattern.

1 Introduction

Treisman and Gelade [3] made a distinction between parallel and serial search. In parallel search, search time is independent of the number of distractors, and in serial search, search time increases with the number of distractors. Treisman and Gelade's [3] feature-integration theory states that a parallel search occurs when a search target is defined by a unique basic feature relative to the distractors. A serial search is found when the search target shares basic features with the distractors.

This theory has been confirmed many times in the visual domain [eg. 4, 5]. Lederman and Klatzky [2] did several search experiments in the haptic domain. They found that some properties produced low search function slopes, indicating more or less parallel search, while others produced relatively steep slopes, indicating serial search.

We wanted to use the theory of Treisman and Gelade [3] to examine whether the same unique spatial features will yield parallel search in the haptic domain as in the visual domain. We therefore designed our experiment to more closely resemble Treisman's experiments by presenting line drawings in a haptic form. We examined whether a parallel search function would appear.

2 Method

2.1 Subjects

Eight subjects, four male and four female, with a mean age of 31.5 (range 24-46), participated in this experiment. Two of them stated to be left handed.

2.2 Stimuli and Apparatus

The stimulus elements were made of ZY®-TEX2 Swell paper and consisted of different figures which protruded about 1 mm from the surface of the paper. The target was a cross and the distractors were circles, with a size of about 70% of the index finger width. They were positioned so that subjects could easily put their fingertips simultaneously on the same place on the stimulus elements. Under each element was a sensor, which measured whether there was a finger on top of it. The sensor was connected to a computer to calculate the search time. Search time was defined as the time that elapsed from the moment the finger touched the target element until this finger was lifted. In the no target condition search time was defined from the moment the first finger touched an element until one of the fingers was lifted.

2.3 Procedure

We presented haptic stimuli to the fingertips of the ring, middle and index finger of both hands of the subjects. The task for the participants was to find the target between the distractors. As soon as they found it they had to lift the finger under which they felt the target. If they couldn't find a target, they had to lift all fingers. The participants were told that they shouldn't make any mistakes and that they should be as quick as possible. Subjects were allowed to move their fingers over the stimuli, as long as they stayed on the same element. A block consisted of 40 trials and had 1 target and either 1, 3 or 5 distractors. The number and position of the items was constant within a block. 25% of the trials didn't have a target. The items were symmetrically divided between the two hands.

2.4 Analysis

For each condition and number of items, we determined for each subject the median reaction time. We tested whether the data represented serial search by a linear regression to all these values of a block. To do so, we reasoned that in serial search, subjects would have searched all elements in the target absent case, and (on average) half of the elements in the target present case. For the regression, we used half of the number of stimulus elements as the (effective) number of elements. This regression yields one slope and one intercept (search time for one element) for the whole block. In order to conform to the tradition in the search literature, we will report the slope in terms of the number of stimulus elements in the target present case (the one in the target absent case is by definition twice as large). As parallel search is assumed to be independent of the number of items, this strategy will result in a zero slope in this serial search model. In order to see whether this pattern of effects was reliable present in our group of subjects, we also performed a repeated measures ANOVA with two factors, number of items (3 levels) and target presence (2 conditions).

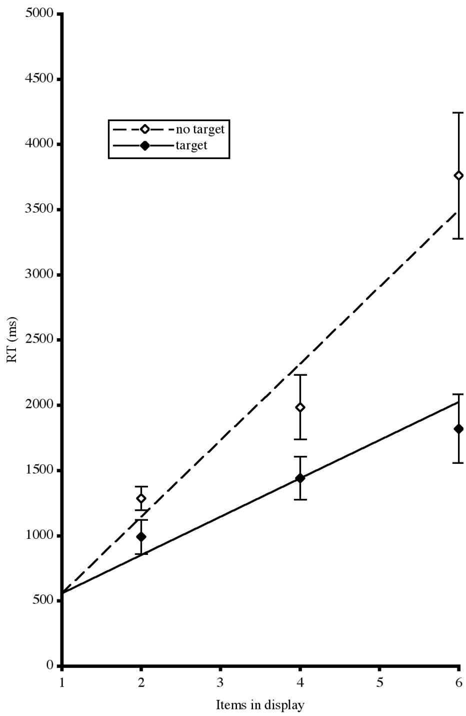

Fig. 1. Haptic search functions; Error bars indicate the standard error of the mean. The lines are the result of the fit of a serial search model to both the target present and target absent trials

3 Results

The results are shown in figure 1. We found a linear relation between the number of items and search time in the target present condition: the slope of the search model is 294 ±54 ms per item; the intercept was 558 ± 290 ms (one item in display). We found a significant main effect of number of items ($p<0.05$) and of target presence (present or absent) ($p<0.01$), and an interaction effect between the two ($p<0.05$).

Subjects seldom made errors. The number of errors depended on the number of items ($p<0.05$). The mean proportion of errors was 0.3% in the 2-item condition, 1.5% in the 4- item condition and 3.1% in the 6-item condition.

4 Discussion

Our serial search model fitted the data very well, with a slope well above zero. The fact that search was serial is quite remarkable as the target 'X' possesses a unique feature (intersection) that is not present in the distractors. We would expect it to yield a parallel search function, as comparable stimuli do in visual search [eg. 6].

Lederman, Browse and Klatzky [1] performed similar haptic search tasks, but did not find a clear serial search. This could have to do with their measurement method. We held the number and position of the items constant within each block of trials. Thus subjects could ignore the 'irrelevant' fingers altogether. Lederman et al's subjects had to determine whether a finger had an item, which might explain why their subjects had shallower slopes and higher intercepts than ours.

The results suggest either that the basic spatial features of touch are very different from those of vision, or that the processing of spatial haptic information is fundamentally different from that of spatial visual information.

References

1. Lederman, S.J., Browse R.A. & Klatzky, R.L. (1988). Haptic processing of spatially distributed information. Perception & Psychophysics, 44(3), 222-232.
2. Lederman, S.J. & Klatzky, R.L. (1997). Relative Availability of Surface and Object Properties During Early Haptic Processing. Journal of Experimental Psychology: Human Perception and Performance, 23, 1680-1707.
3. Treisman, A.M. & Gelade, G. (1980). A Feature-Integration Theory of Attention. Cognitive Psychology, 12, 97-136.
4. Treisman, A.M. & Gormican S. (1988). Feature Analysis in Early Vision: Evidence From Search Asymmetries. Psychological Review, 95, 15-48.
5. Treisman, A.M. & Souther, J. (1985). Search asymmetry: A diagnostic for preattentive processing of separable features. Journal of Experimental Psychology: General, 114, 285-310.
6. Gleitman, H. (1995). Psychology. Fourth Edition. New York: Norton & Company, Inc.