Student exchange program for cross-disciplinary fertilization

Project title:
Optimising haptic search through visual feedback

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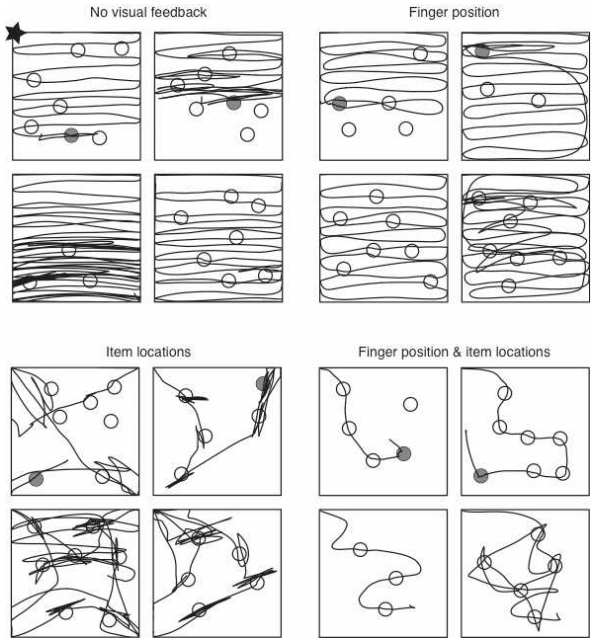
Project aims and results:
While we perform haptic searches on a daily basis when we take our key out from our pocket or try to find a light switch in the dark, only little research into haptic search has been done. Visual search, on the other hand, has been researched extensively and various models of the underlying mechanism have been proposed. Typically, the task for the subjects is to respond as fast as possible whether a certain target item (for instance a red dot) is present among varying numbers of distractor items (for instance green dots). Response times can then be measured as a function of the number of items. Recently, haptic search has been gaining attention from the scientific community. This project aimed at providing insight into the differences between haptic and visual search and how well visual information can be used to guide haptic search.

In the visual modality a division has been made into *parallel* and *serial* search. If search is performed in parallel, all items are processed simultaneously and response times are independent of the number of items (pop-out effect). In serial search items are processed sequentially and response times increase with the number of items. In this case the slope of the response times as a function of the number of items for target absent trials is usually twice as large as the slope for the target present trials. This is because if a target item is present on average only half of the items are visited, while in target absent trials all of the items have to be visited. For haptic serial search slopes this model does not seem to hold. A possible explanation for this difference between the modalities is that in vision there is information from peripheral vision about the layout of the display in terms of the positions of the items (and therefore possible target positions). In haptic serial search this information is not present. Therefore, it can be expected that adding this type of visual information to a haptic search task will make haptic search more similar to visual search. To investigate this, a multimodal haptic and visual search task was designed. The experiments were carried out at the Max Planck Institute for Biological Cybernetics.

The haptic stimulus was presented using a PHANToM force feedback device. Subjects placed the index finger of the dominant had in a thimble like holder connected to the force feedback device. The haptic display consisted of a bounded 15 $\times$ 15 cm^2 area on which 3, 5 or 7 items could be displayed and on half of the trials a target items was present. The items were defined as having larger static and dynamic friction than the display background. The target always had larger friction than the distractor items. The visual stimulus was presented through a mirror spatially aligned with the haptic stimulus. There were four different visual conditions. In the *no visual feedback* condition only a square indicating the boundaries of the display were shown. In the *finger position* condition also the finger position was shown, while in the *item positions* condition the boundary square and the item locations were shown. Finally,

in the *full visual feedback* condition the bounding square, finger position and item positions were shown. Note that the haptic display was defined in the same way for each of conditions and the target could always only be identified haptically. Subjects always started with their finger and the upper left corner and were instructed to search the display and respond as fast as possible whether the target item was present. It was also emphasised that it was important that the answer was correct.

In the Figure below a selection of tracks from one subject in each of the conditions is shown. Always two target present and two target absent trials are shown and a filled grey disk indicates a target. In the Figure it can be seen that there is a clear strategy difference between the conditions with visual information about the item positions and the conditions without this information. Without visual information about item positions, the subjects systematically scanned the whole display from edge to edge. As a result, response times did not significantly increase with the number of items for these two conditions. When there was visual information about the item positions, the response times did increase significantly as a function of the number of items. Analysis of the movements over the display showed that subjects revisited items (move onto an item then move to another item and back the previously visited item) in each of the conditions and specifically in target absent trials.



In visual search it is sometimes assumed that subjects do not revisit items (inhibition of return). Our results show that in haptic search there is no inhibition of return even if there is visual feedback on item and finger positions. Furthermore, our results show that adding visual information about item positions makes haptic search more efficient even if there is no visual feedback on the finger position. Finally, our results show that slopes as a function of the number of items did not increase with the number of items without visual information about item locations and they did increase when this information was present. In vision these search slopes are often used to distinguish parallel and serial search. In the present study, we found slope differences while search could only be performed serially in each of the conditions. This shows that the search slope is not a reliable indicator for parallel search and that analysis of the search strategy in terms of exploratory movements can be crucial for distinguishing parallel and serial search in haptics.