Head and eye movements in a widespread stimulus comparative search paradigm

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Introduction

From recent studies on the phenomenon of change blindness [1] or the block copying task [2] it is known that the capacity of the visual working memory is limited. From this findings it follows that there is a trade-off between the use of working memory and *eye* movements in terms of their cost to optimize the visual performance. It could be shown, that increasing the costs of *eye* movements alone, by demanding longer saccades, leads to increased memory use in a comparative visual search task [3].
In our investigation we extent this study by measuring the gaze behavior, i.e. head movements are included. Two shelves, spaced at different intervals are used in a comparative search paradigm. With larger shelf distance the costs for gaze behavior raised up. Since there is a trade-off, memory usage become more important and the number of gaze shifts between the shelves should be decreased.

Material & Methods

Apparatus: - Curved, tilted, conical screen with 150° and 70° angle in horizontal and vertical direction — enables a large field of view (fov)
- Subjects in 1.62m distance, *eye* level at 1.2m (Figure 1)
- Eye movement recordings with a head mounted, infrared light based *eye* tracker (model: ASL-501).
- Head movement recordings (6dof) with the infrared based system ARTtrack| Dtrack
- Sample rate of both systems: 60 Hz
- Measured gaze position with an error of less than 2° of visual angle

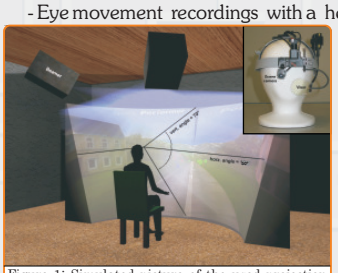

Figure 1: Simulated picture of the used projection screen with the two video projectors (main). Also shown the mobile, head mounted eye tracker (small).

Subjects: - 30 students participated (age: 23-34 years), 18 excluded because their *eye* data contain more than 15% of tracking losses

Stimulus: - Two shelves filled with simple geometrical objects in four forms (triangles, circles, squares and rhombs) and in four different colors (green, blue, yellow and black)
- Each shelf includes 20 objects (Figure 2)
- Objects' configuration in the shelves was identical except for 0, 1, 2 target positions, where the objects' shape was different.
- Four different shelf distances (30°, 60°, 90° and 120°) to increase the need for head and *eye* movements
- For each distance three trials for each target condition → one experiment with 36 trials in random order

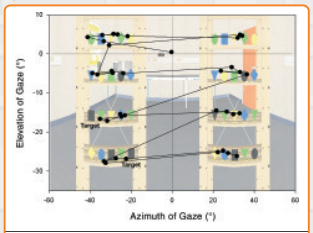

Figure 2: Two targets sample trial of the shelf comparing experiment with overlaid example gaze scanpath for a 30° shelf distance. Gaze angles are calculated as azimuth and elevation.

Task: - Find the number of differences (as quick and reliable as possible)!

Conclusions

- In this comparative visual search task experiment we found an increase of fixation duration and a decrease in the number of gaze-shifts between the both shelves (hemifields). Both curves indicate a saturation stage to the end (Figure 5). This could be a hint for the limitation of short term memory use in this task. We could confirm the results of a recent study [3] additionally for gaze, including large head movements. Lifting up the costs for *eye* and head movements will increase the visual working memory usage.

- Furthermore we found a strong preference in fixation number for one of the both hemifields. The results divide the subjects into two groups: left hemifield and right hemifield subjects. This leads to the assumtion that a possible strategy of the participants needs a memorizing (more fixations) and a comparison (less fixations) hemifield. Also the longer fixation durations in the prefered hemifield support this gaze behavior strategy (Figure 6 and 7).

Results

- The error rate did not vary significantly with the distance between the shelves, $F(3;44) = 1.067$, $p = 0.37$ with 3.24%, 4.17%, 4.86% and 5.78%.

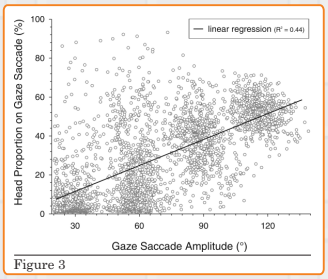

Figure 3

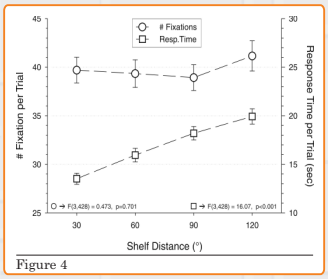

Figure 4

- Linear increase of the head portion on gaze saccades depend on the saccade amplitude. With the largest shelf distance (120°) head movements reach 51.5%.

- There is a sign. increase between response time and shelf distance in a linear relation. The fixation number per trial is not sign. affected by the shelf distance.

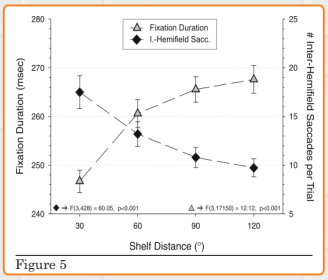

Figure 5

- Fixation duration is sign. increased with larger shelf distance.

➡ increased informational load

- Number of gaze saccades between left and right hemifield is sign. decreased.

➡ reduced head movement costs

Comparative Search Strategy

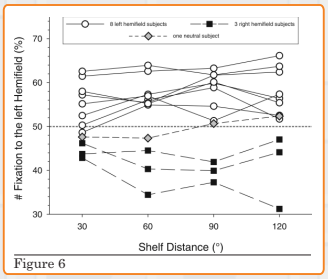

Figure 6

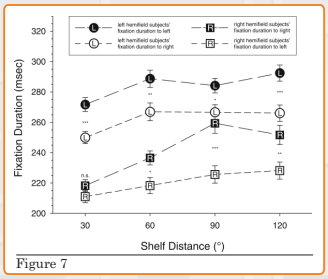

Figure 7

- 8 subjects directed more than 50% of all fixations to the left hemifield (extreme case: over 62%)
- 3 subjects directed more than 50% of all fixations to the right hemifield (extreme case: more than 65%)
- 1 subject showed no preference

- Left hemifield subjects' fixation duration to the left (prefered side) is sign. increased.
- Right hemifield subjects' fixation duration to the right (prefered side) is sign. increased.

➡ **More and longer fixations in the prefered hemifield**

References

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