The Influence of Motor Costs on Visual Search When Reaching for Target Objects

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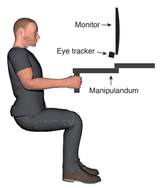
Introduction

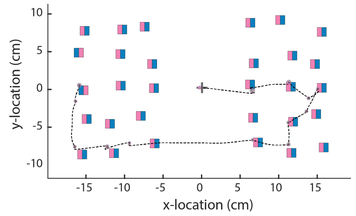
- In real world tasks, visual search is often carried out in order to locate objects we intend to act on. However, research on visual search has not considered how motor costs, associated with action, might influence search.
- Recent work has shown that motor costs associated with responding can bias perceptual decision making in visual motion discrimination tasks [1,2].
- The aim of the current study was to assess whether visual search can likewise be biased by motor costs associated with acting on located targets.
- In our task, participants had to search for, and then move a handle to, targets that could be located on either the left or right side of the search environment. Different resistive forces could be applied, through the handle, to movements on the left and right sides.
- **Hypothesis**: Search will be biased towards the side where there is less resistive force, and hence lower motor costs.

Methods

Apparatus



Exemplar Trial



Participants

36 right-handed participants, 27 female, M_{age}= 20.44, SD= 2.97

Procedure

- The side of the search space with larger forces applied was counterbalanced across participants.
- In each trial the participant had to locate one of two target objects and then reach towards it with the handle. In the spatial load condition, forces were applied to this outward reach. In the object load condition, the participant had to 'drag' the object back to the start position and forces were applied to this return movement.
- The two target were randomized such that in 25% of the trials both targets were on the left side, 25% of the trials both targets were on the right side, and 50% of the trials, there was one target on either side.

Experiment 1: Spatial and Object Loads

Baseline (30 Trials) → Test (180 Trials) → Washout (30 Trials)

= Both sides set to 10 Ns/m

= One side set to 30 Ns/m and the other at 10 Ns/m

Experiment 2: Training on the Forces

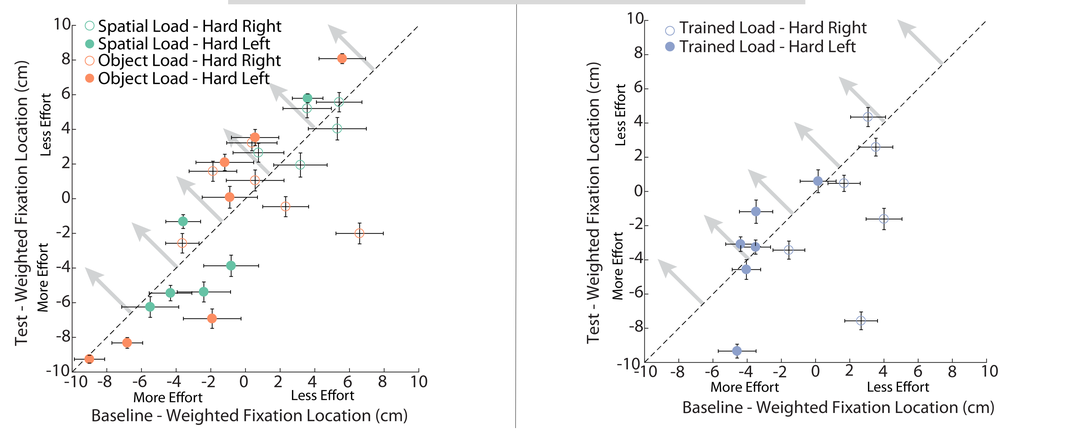
Baseline (60 Trials) → 1- Target (30 Trials) → 2- Target (90 Trials) → Test (and Probe) (180 Trials (20 Probe))

Results

Experiment 1: Spatial and Object Load

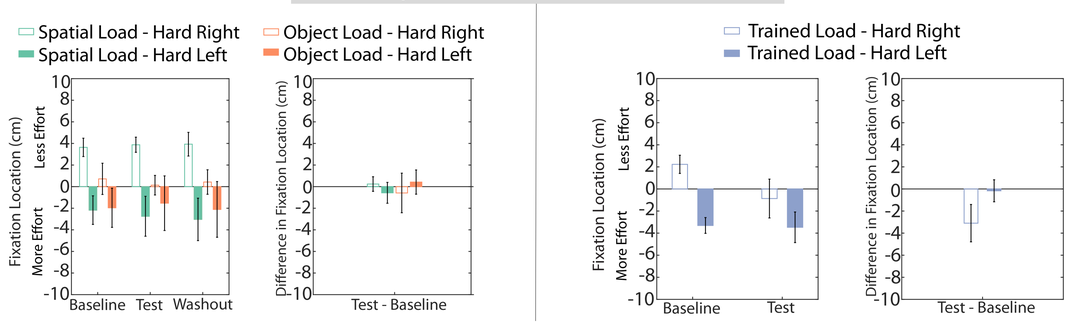
Experiment 2: Training on the Forces

Individual Fixation Location Bias



Figures 1 and 2. Individuals average baseline fixation location compared to test trials. Arrows indicate the hypothesized direction of the effect, where participants above the line biased gaze towards the force minimum side more during the test phase than baseline.

Group Fixation Location Bias



Figures 3 and 4. Group averaged fixation locations: for filled bars negative values indicate fixations on the left side, for open bars positive values indicate fixations on the left side. Difference scores of test compared to baseline are also shown where positive values indicate a gaze bias to the force minimum side during the test phase as compared to baseline.

Reaching Bias

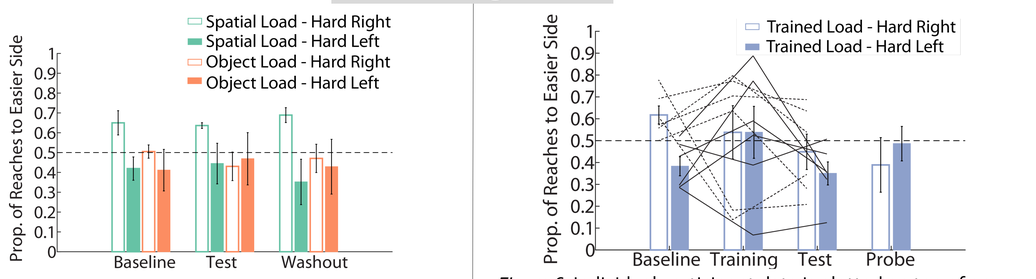


Figure 5. The proportion of reaches to the force minimum side during trials where there was one target on both sides of the screen.

Figure 6. Individual participant data is plotted on top of group averages. Dotted lines indicate participants in the force on the right condition, and solid lines indicate participants in the force on the left condition.

Results

- **Experiment 1**: ANOVAs were carried out to assess the effects of phase (baseline, test, washout), side (force right, force left), and condition (spatial load, object load) on weighted fixation location and reach direction.
- **Experiment 2**: ANOVAs were carried to assess the effects of phase (fixation: baseline, test; reach: baseline, training, test, probe), and side on the same variables.
- No effects were found for phase, p>.05, when analyzing fixation and reaching data in both experiments.
- A leftward bias was found in all cases, indicating that participants looked and reached towards the left side more, and this did not change after the forces were introduced.

Discussion

Summary

- We did not find evidence that search is biased by motor costs, as search behaviour remained consistent with baseline behaviour after forces were introduced.
- Both fixations and reaching data showed a clear overall left bias, where participants tended to look left regardless of whether that was the force minimum or force maximum side
- Unexpectedly, we did not find that participants consistently selected targets on the low force side during 2-Target training trials when search was not required.

Future Directions

- It's possible that the forces imposed on the handle were not strong enough to bias search, and perhaps some threshold of effort must be met before search is biased.
- The tendency to use, and stick with, a certain search strategy may have overpowered the implementation of motor cost avoidance [3].
- Factoring into account motor costs in our task may require attentional resources and be effortful [4]. It is possible that the ability to integrate these forces into search did not occur because of the competing demands of the search task.
- It is surprising that motor costs did not influence search in 2-target training trials given that previous experiments have shown clear effects of motor costs on decision making [1, 2]
- A future study could associate motor costs with search itself by requiring participants to control a 'search window' with the handle, to which forces are applied.

References

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