Reaching movement accuracy is mainly determined by visual on-line control

Hugo Bruggeman[2], Carlo Fantoni[1], Corrado Caudek[3], Fulvio Domini[1,2]
1: *Italian Institute of Technology,* Center for Neuroscience and Cognitive Systems, Rovereto (TN), Italy
2: *Brown University,* Department of Cognitive and Linguistic Sciences, Providence, RI, USA 3: *University of Florence,* Firenze, Italy

Motivation

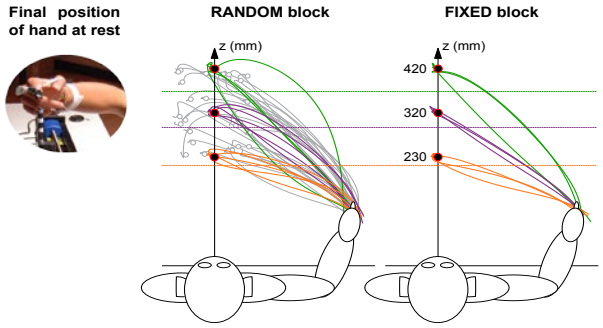
We studied the temporal evolution of reach movements in response to the presence/absence of binocular cues. Monocular and/or binocular information was present in different segments of the hand movement trajectory in an object's reaching task. Accuracy in finger's alignment with the target can be explained by two different theoretical approaches.

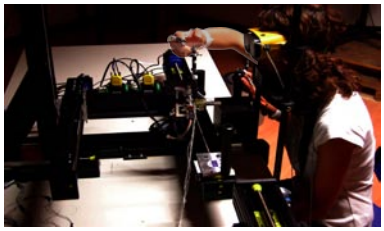
- **METRIC APPROACH: Reach movements are guided by an internal metric representation of the target's location and this representation is updated in time. If disparity information is removed at the very end of the hand movement (i.e., after reaching about 90% of egocentric target distance), the decrement in performance should be minimal because, at this stage, the internal metric representation is sufficiently consolidated (e.g., Greenwald & Knill, 2009).**
- **DIRECT APPROACH: sensory information directly specifies target's location - no inferences about metric depth are required. For disparity information, for instance, a nulling strategy can be used, which only requires to concurrently reduce the crossed (near) and uncrossed (far) disparities between target and hand (e.g., Melmoth, Storoni, Todd, Finlay, & Grant, 2007). The removal of disparity information at the very end of hand movement should have a substantial effect, because visuomotor behavior depends (for the major part) on the sensory information available at any given moment (it is not mediated by an internal metric representation updated in time).**

Method

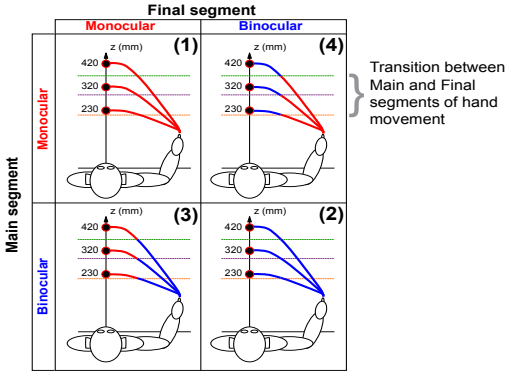
We studied reaches at three different target distances along the line of sight (*probe trials* at 230, 320, and 420 mm). In the RANDOM block, the probe trials were intermixed with other trials in which the target positions were randomly varied on the x-z plane. The FIXED block only included the probe trials. *Task:* participants were asked to align their index finger with the target without touching it.

We manipulated the visual information (monocular/binocular) provided in two contiguous segments of the hand movement. *Main Segment*: from the movement onset up to 60 arcmin of relative disparity between finger and target. *Final segment*: from 60 arcmin of relative disparity until the end of the movement. Four Viewing Conditions were tested. (1) Both Main and Final segments of the movement were monocular. (2) Both Main and Final segments were binocular. (3) Main segment: binocular; Final segment: monocular. (4) Main segment: monocular; Final segment: binocular.

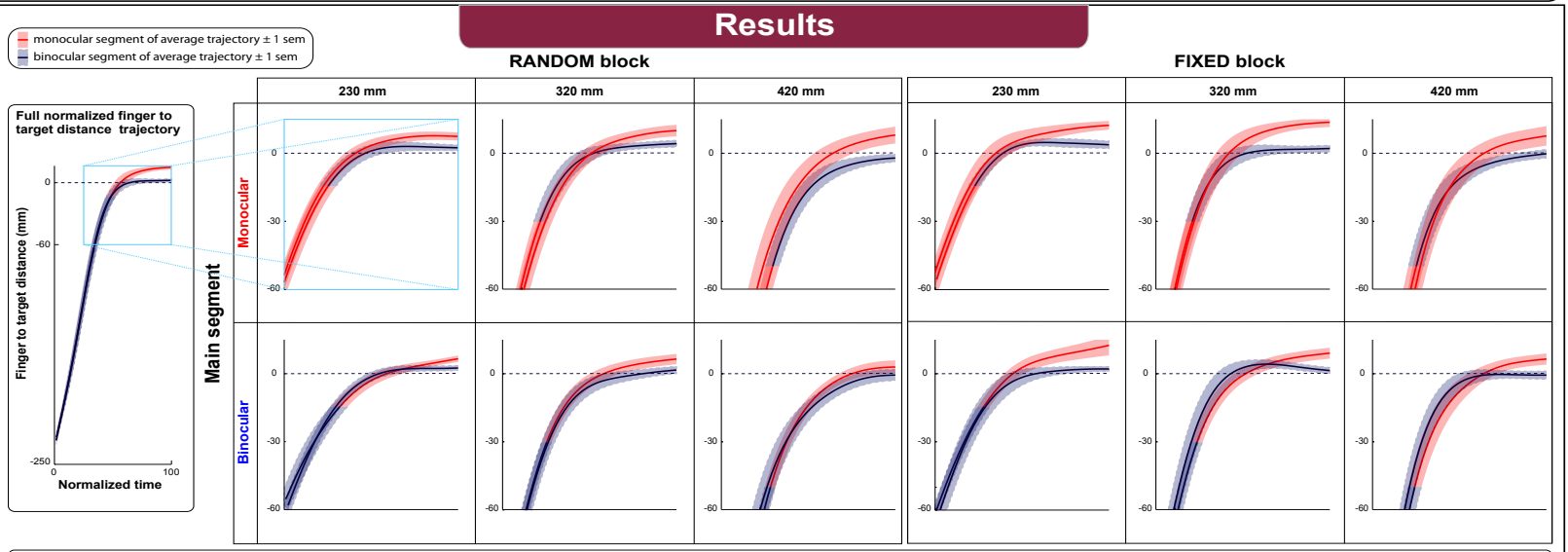




A pair of LCD goggles could switch between binocular and monocular viewing depending on the experimental condition. Hand movements were recorded by using an Optotrak Certus system. The location of the target was varied through computer controlled linear actuators.

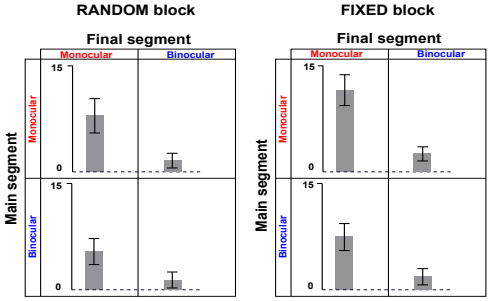


Results



Finger-to-target distance as a function of normalized time. Trajectories were averaged across 11 participants by first stretching or compressing each trajectory (from the onset to the end of the movement) to a common (arbitrary) duration.

Final offset



Conclusions

Binocular cues provided during the Main segment of hand movement (from movement onset up to 90% of the egocentric target distance) do not improve accuracy of reach movements with respect to a fully monocular reach.

This result is even stronger when participants always reached at the same three target locations (FIXED block) rather than when these three target locations were intermixed with targets that randomly varied on the x-z plane (RANDOM block).

- **These findings are incompatible with the hypothesis that a metric 3D representation is consolidated during the temporal development of reach movements.**
- **These findings suggest that performance in the present task may be mediated by a simpler mechanism which directly maps motor execution to sensory information.**