Multisensory interactions mediating motion perception on the hand

Catalina Feistritzer[1], Himanshu Ahuja[1,2], Sabyasachi K. Shivkumar[1,2], Ralf M. Haefner[1,2], Gregory C. DeAngelis[1,2], Manuel Gomez-Ramirez[1,2]

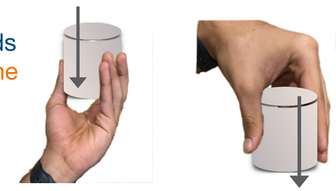
[1]Center for Visual Science, [2]Department of Brain & Cognitive Sciences; University of Rochester, Rochester, NY

THE HAPTICS LAB

EXP. 1: The proprioceptive state of the arm influences perception of tactile motion

- Tactile motion perception is key to manipulating dynamic objects in our environment
- Tactile motion has generally been studied in only one posture *(e.g. Pei et. al 2008, 2010, 2011)*, but different postures impact how motion is interpreted (figure 1):

Downwards Towards the palm



Downwards Away from palm

Figure 1

- Visual studies show that motion can be interpreted through multiple reference frames. In a previous study, we found that posture can change the motion percept, but in a reference frame dependent manner (figure 2).

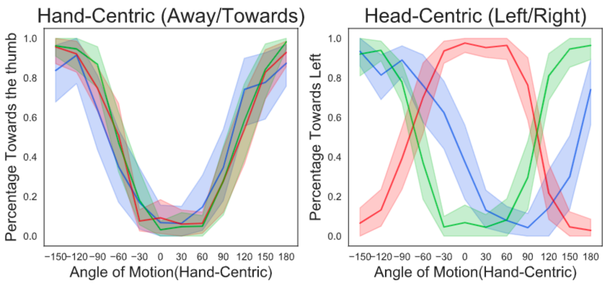
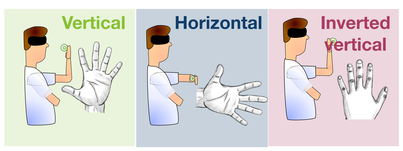


Figure 2: In the hand-centric task, subjects discriminate the direction of a motion stimulus to be towards or away from the thumb; in the head-centric task, they discriminate between left or right with respect to the sternum

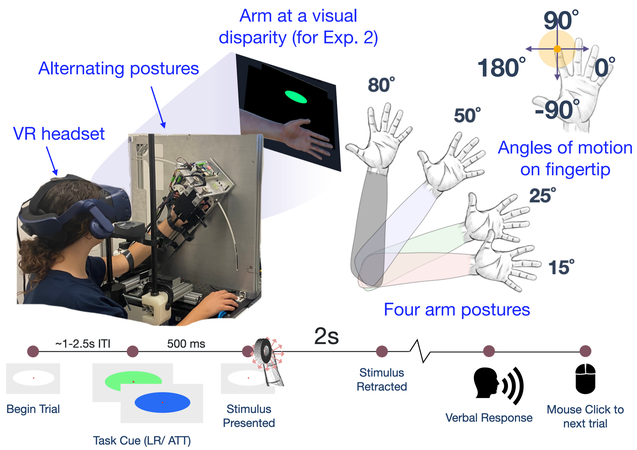


Drawbacks

- Blocked posture design might lead subject to implement cognitive strategies to perform the task, and rely less on integrating the proprioceptive and tactile stimulus.
- Low number of individual trials; found varying individual bias.

- **Confirm that shifts from previous experiment result from posture changes, not cognitive effects**
- **Determine if sensitivity of motion discrimination is higher in one reference frame over the other**
- **Identify proprioceptive threshold for motion discrimination changes**

METHODS:



RESULTS

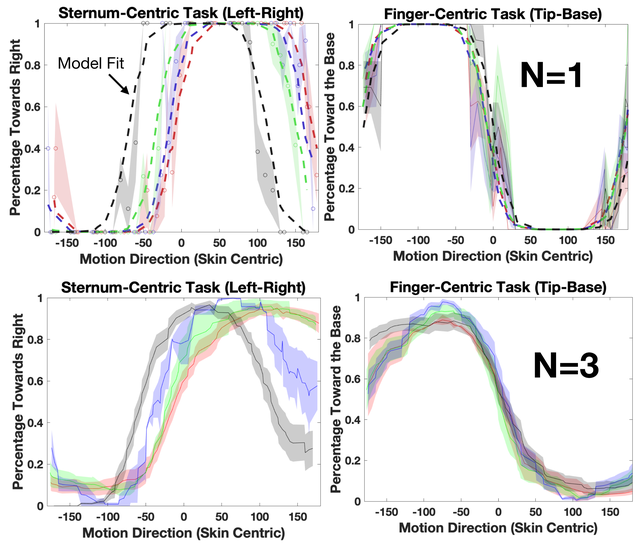
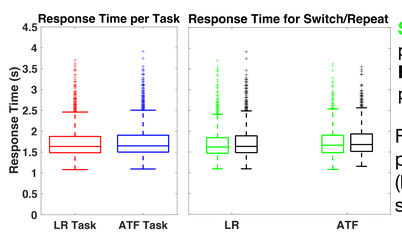


Figure 3: Typical individual subject data (above) with model fit (dotted line), and population level data (below).

15° 25° 50° 80°



Switch (previous trial performed was other task)
Repeat (previous trial performed was same task)

Figure 4: Reaction times of population data per task (left) and per repetition or switch of task (right)

RESULTS, CONT.:

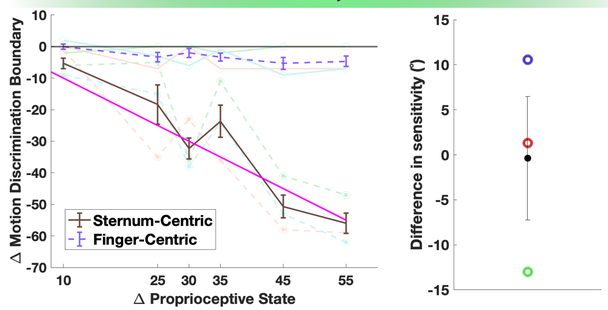
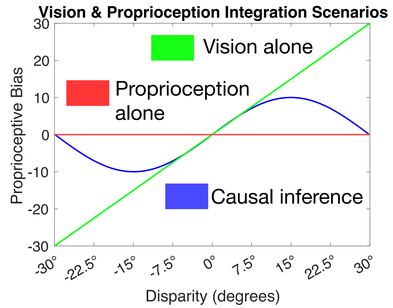


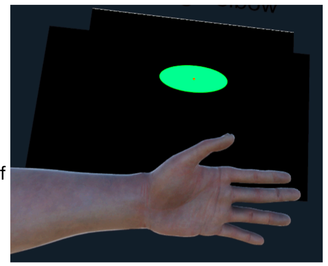
Figure 5: ***Left***, Changes in perceived motion discrimination boundaries at different posture differences in the two tasks. Ideal case for the sternum-centric task (magenta), and finger-centric (black). Faded lines are individual subjects. ***Right***, Difference in sensitivity between the Finger-centric and Sternum-centric task in individual subjects (unfilled markers), and average across subjects (N=3, filled marker). Error-bars represents standard error.

EXP. 2: How visual cues of the arm influence tactile motion perception



HYPOTHESIS: Increased disparity of the proprioceptive state of a virtual arm from true arm will INCREASE proprioceptive bias; at large disparities, proprioceptive bias will disappear (causal inference model)

METHODS



Changes:

- Only one posture (50°), but random postures in between.
- New VR display includes **virtual arm**
- Varying disparity of virtual arm from true arm
  - Up to 30° disparity

RESULTS

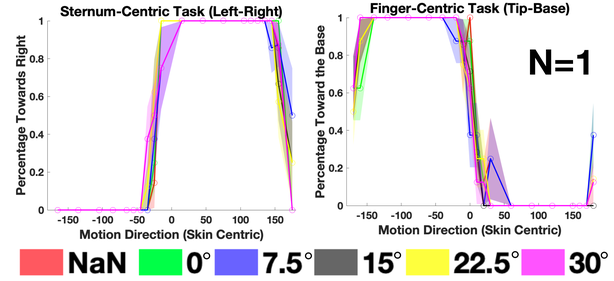


Figure 6: Psychometric curves at various visual disparities (50° posture only). Participant was a non-naïve subject.

CONCLUSIONS

- Arm posture modulates tactile motion perception in a reference frame-dependent manner
- Reaction times suggest that subjects can flexibly switch between reference frames
- **Preliminary data** suggests that participants have similar sensitivities to motion direction judged in different reference frames
- Proprioceptive threshold generating changes in motion discrimination boundary appears to be between ~ 10-25°
- Visual signals conveying arm position/posture do not appear to impact motion discrimination
- **Our findings indicate that perception of motion signals on the hand is formed through the integration of tactile and proprioceptive signals in relation to the reference frame upon which the judgement is being made in.**

ACKNOWLEDGEMENTS

- University of Rochester's CVS Summer Program
- Alfred P. Sloan Foundation
- Haptics Lab member