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Multisensory Interaction of Visual and Proprioceptive Cues in Tactile Motion Perception

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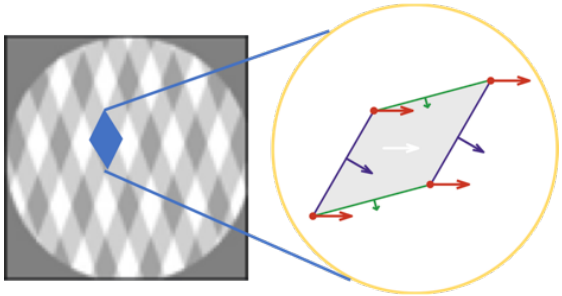
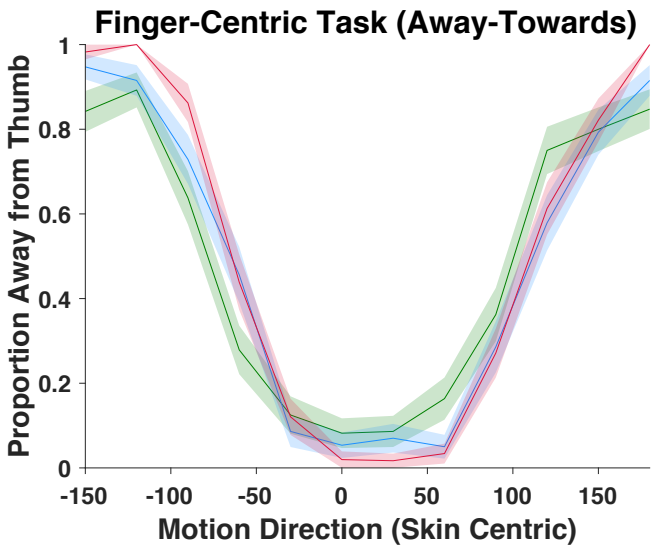
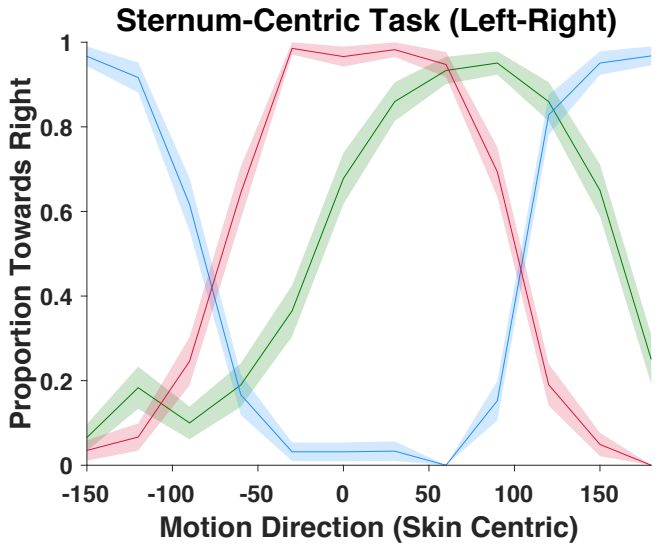
Tactile motion perception is modulated by arm posture & reference frame

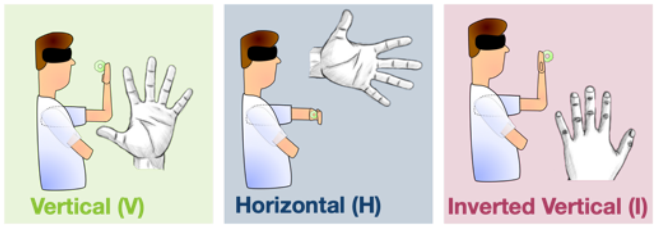


Different components of a plaid

Pei et al., 2011

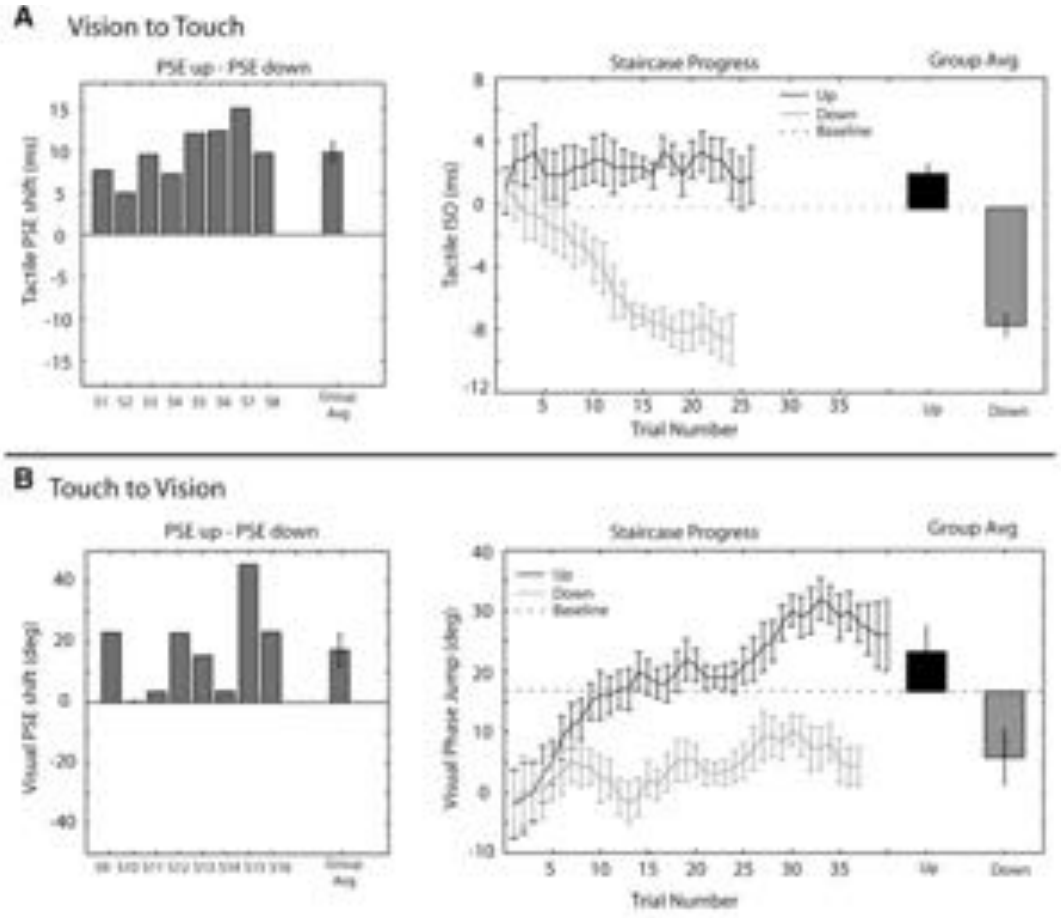






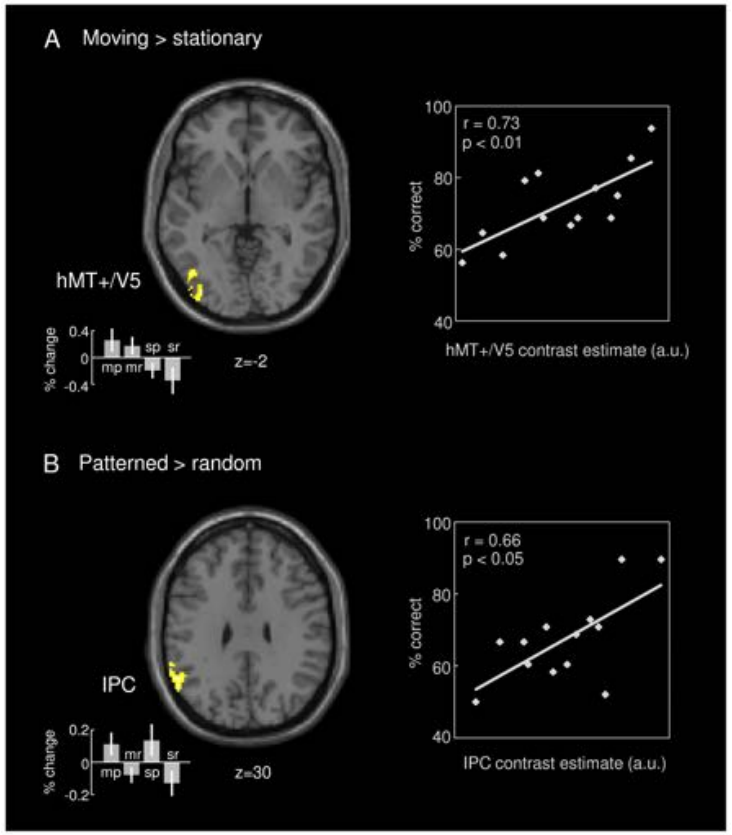
Himanshu Ahuja - Poster #5129, 2021

Tactile and visual motion perceptual systems interact

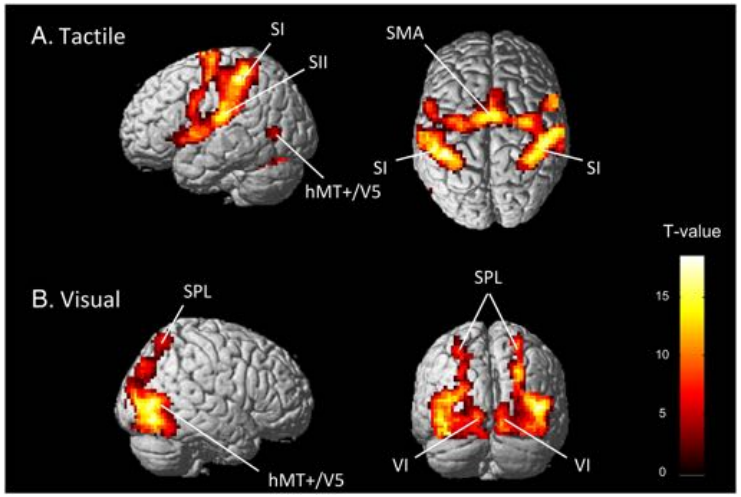


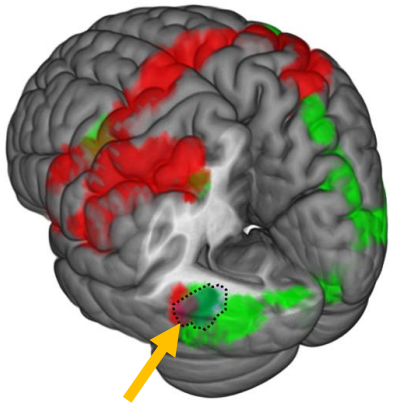
Konkle et al., 2009

Visual area MT activates in response to tactile motion stimuli



Wacker et al., 2011





Overlapping activity

Tactile activity

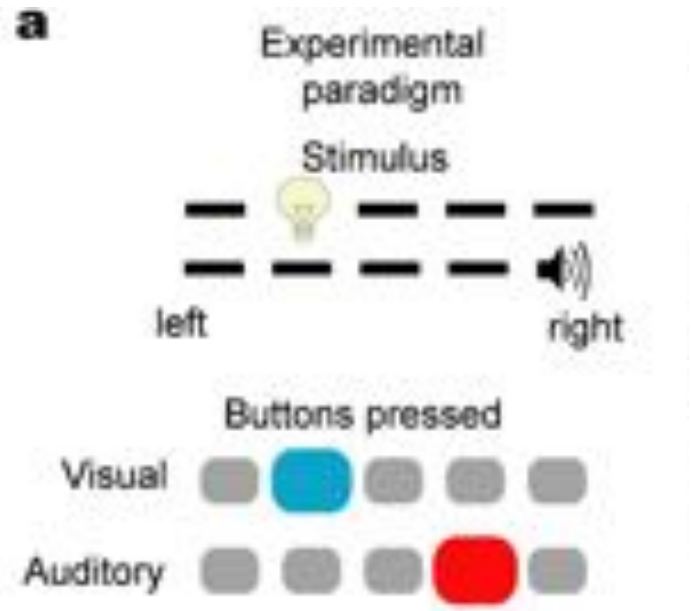
Visual activity

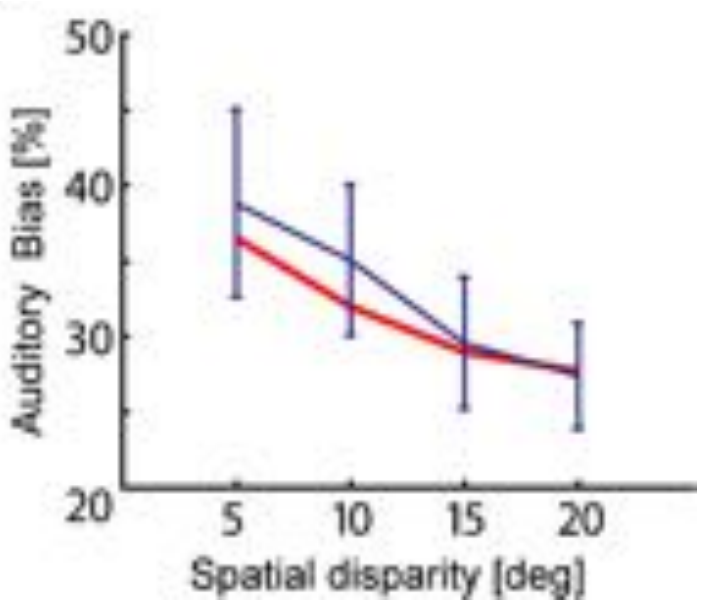
Kemenade et al., 2014

How visual and tactile signals interact to generate motion representations remains elusive

- A theoretical framework for how visual and tactile signals interact to generate motion representations on the hand is lacking
- Do visual signals modulate one's perception of tactile motion?
- Studies suggest that tactile and visual signals are integrated according to a causal inference model

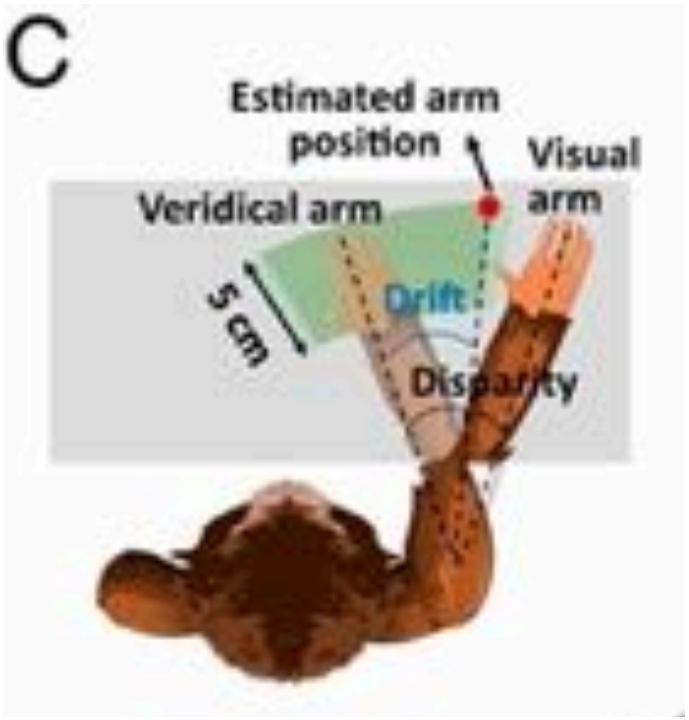
Causal inference model could explain tactile & visual information integration process in brain

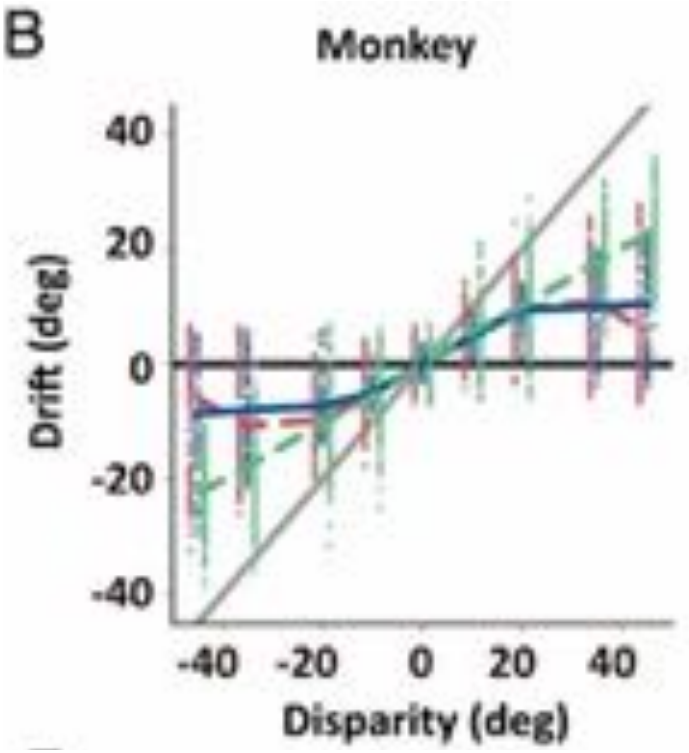




Körding et al., 2007

Causal inference model can explain proprioceptive drift in tactile localization





Fang et. al., 2019

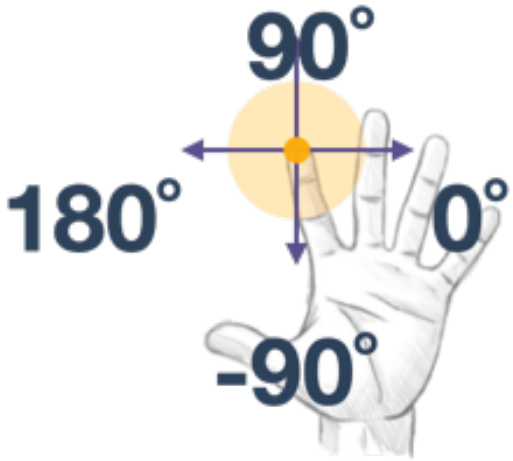
Tactile motion integrates visual inputs using causal inference mechanisms

- We test the hypothesis that tactile motion system integrates visual signals encoding proprioceptive state of the arm according to causal inference model.

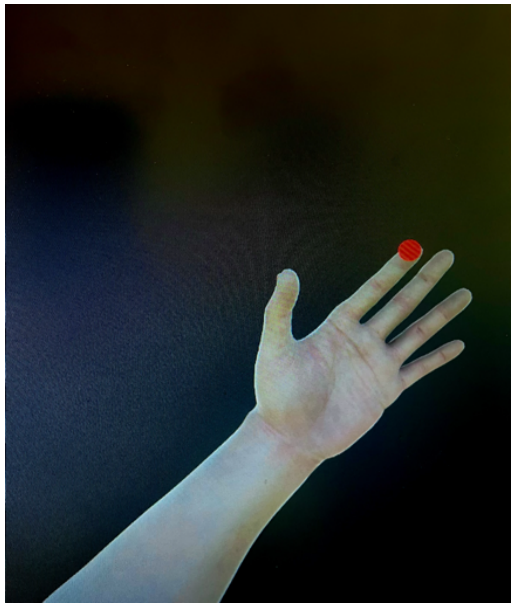
- These visual, tactile, and proprioceptive interactions are reference frame-specific, only taking place during motion judgements referenced to the sternum

Task design

Virtual reality headset & arm secured in mobile robotic exoskeleton

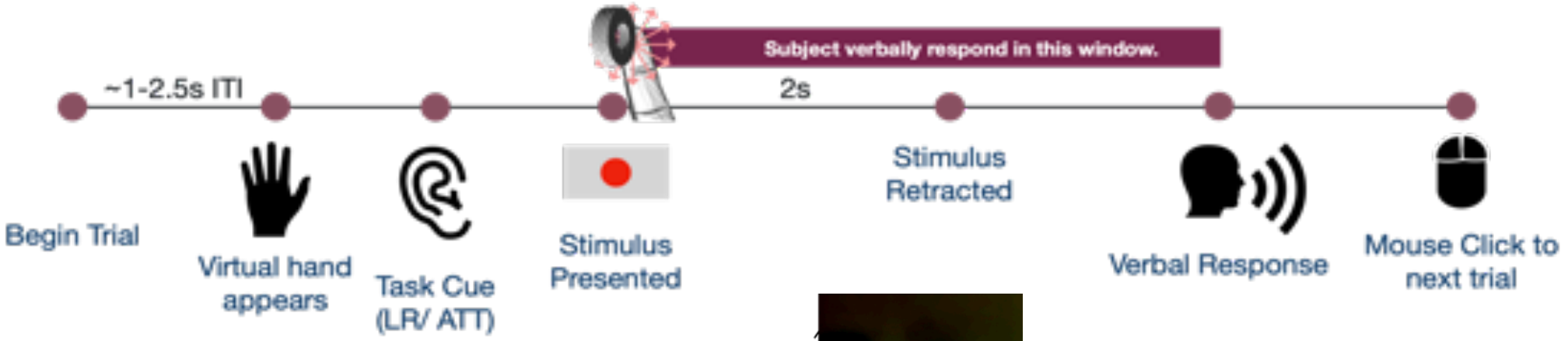


Angle of motion on skin provided by dot-wheel stimulus

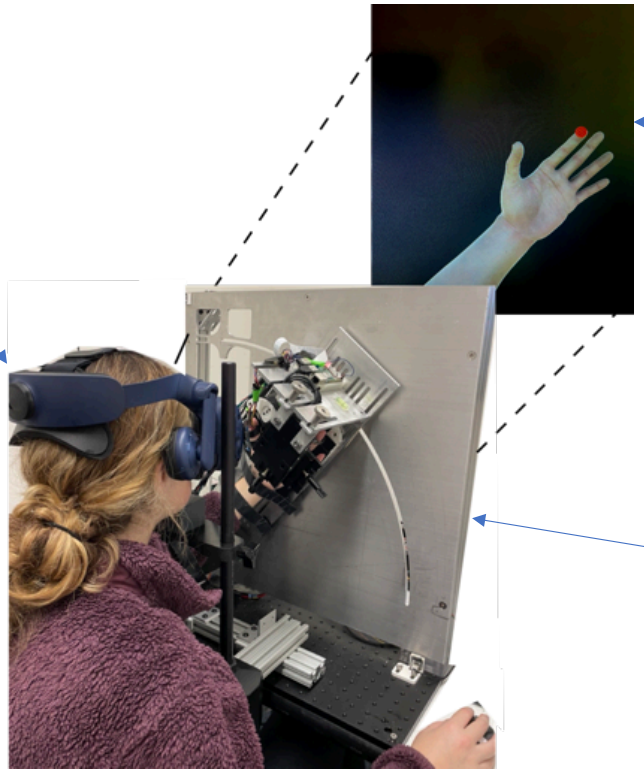


Virtual arm presented in virtual reality headset

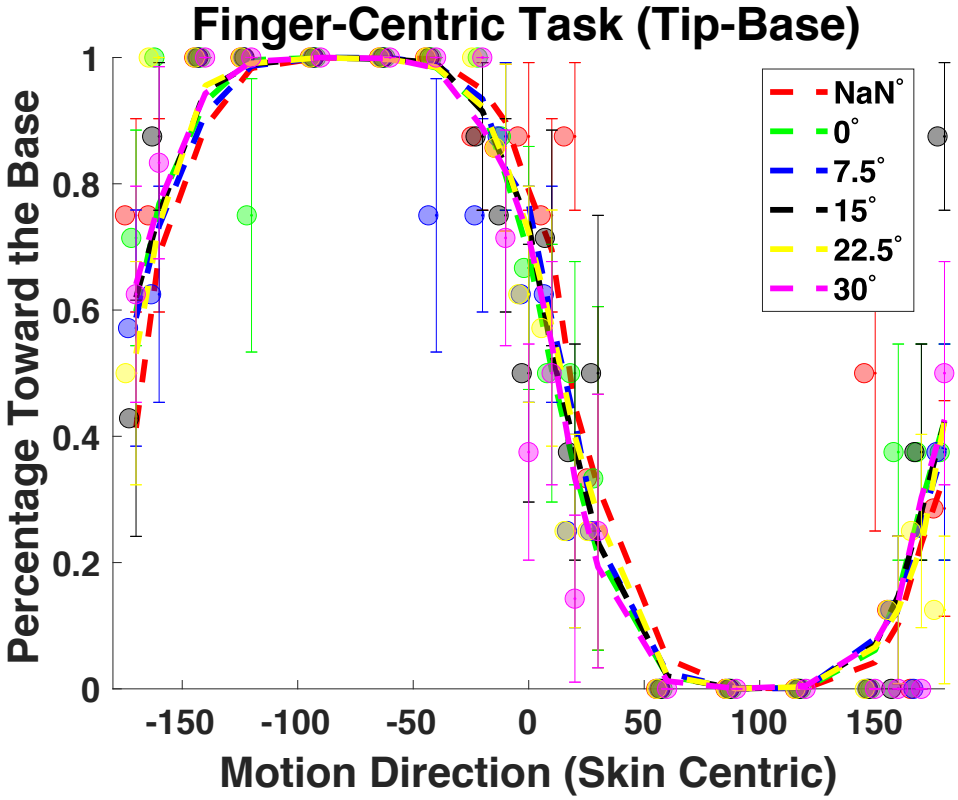
- Audio prompt for 2-AFC task:
  - “Finger” = hand-centric task (tip or base of finger)
  - “Head” = sternum-centric task (left or right)

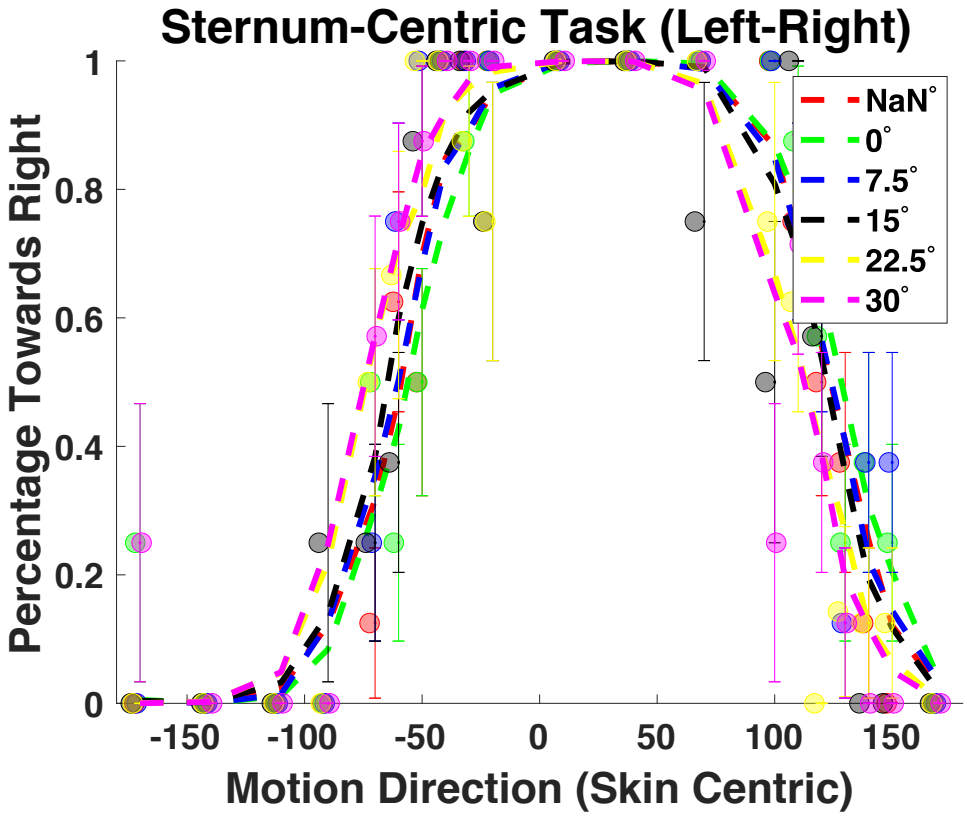


EXPERIMENTAL TIMELINE

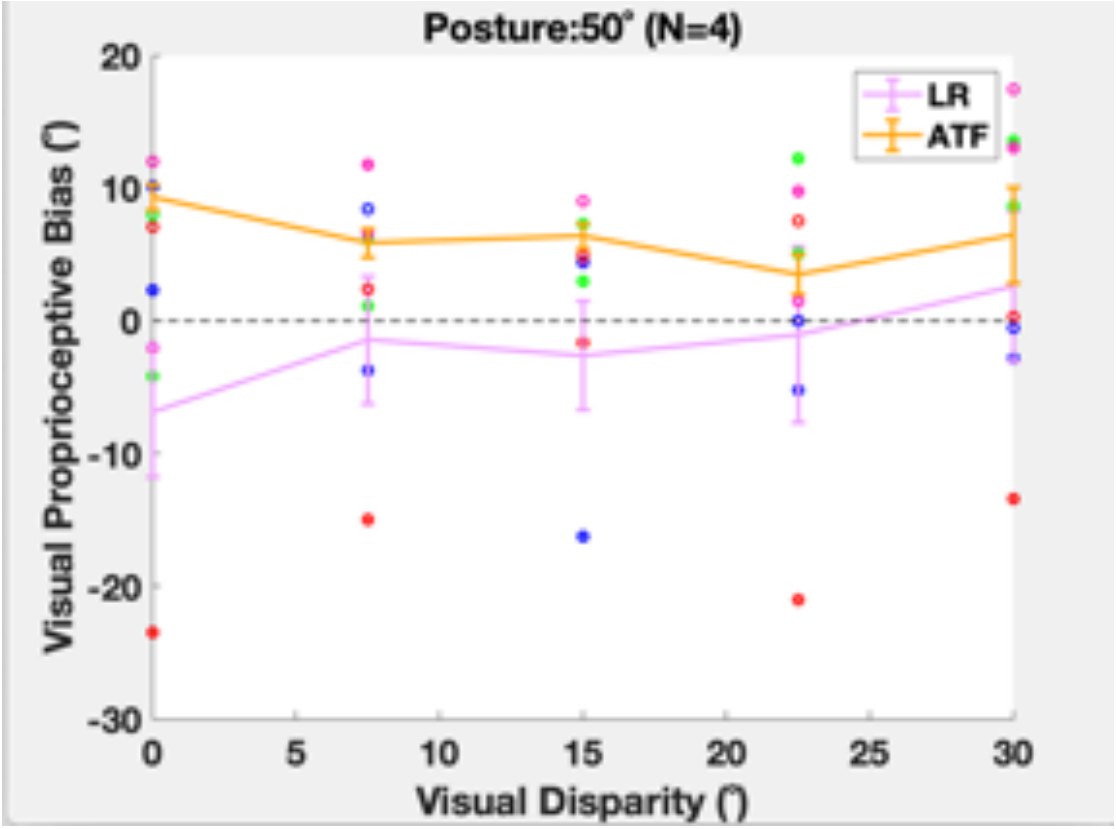


Proprioceptive cues continue to be integrated when visual cues are provided





Causal inference does not seem to account for visual and tactile motion interactions



Conclusions

- Visual signals encoding proprioceptive inputs modulate perception of tactile motion regardless of reference frame instructions

- Pilot data does not seem to support the hypothesis that visual and proprioceptive signals are integrated using causal inference (more data are needed to confirm)

- These data provide further evidence that tactile motion representations are mediated by multisensory neural circuits that integrate tactile, proprioceptive, and visual signals of the hand.

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