A Left-Hand Advantage

Motor Asymmetry in Touchless Input

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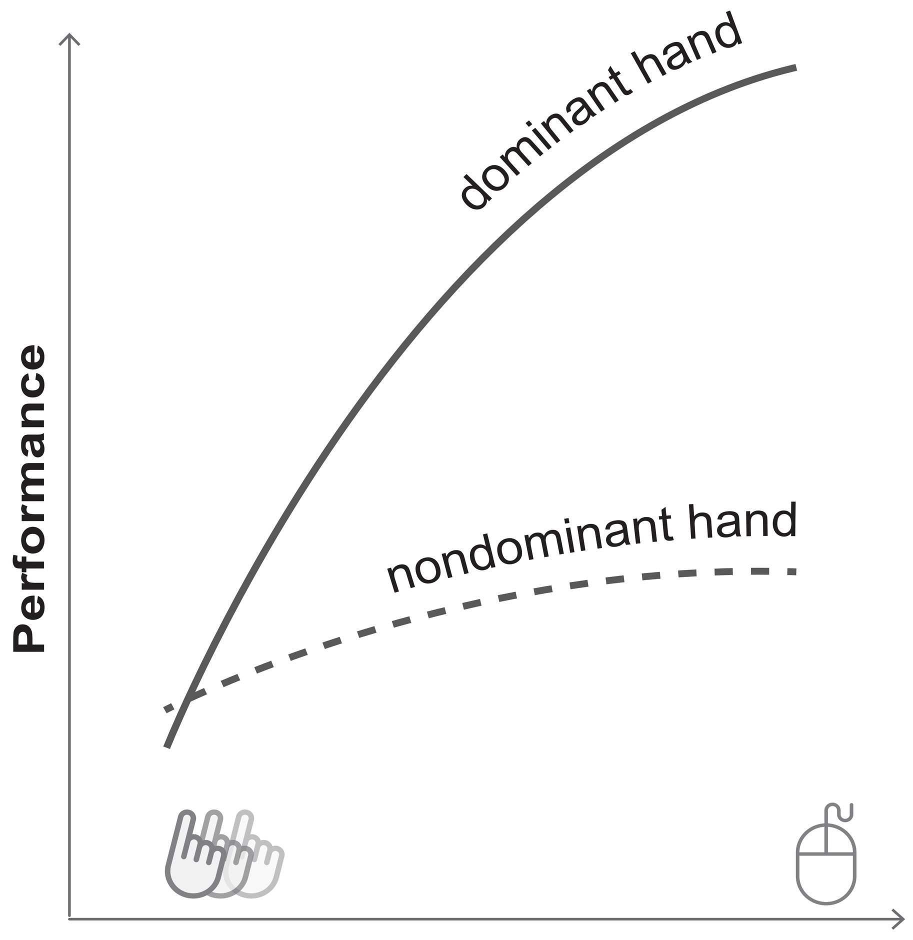
Motivation

- Touchless gesture is a common input type when interacting with large displays or VR/AR applications. In touchless input, users may alternate between hands or use bimanual gestures.
- User performance in nondominant (or non-preferred) hands when using different input devices has been studied in the past. But touchless performance in nondominant hands is little explored.
- Our work is motivated by cognitive science and neuroscience studies that show cerebral hemispheric specialization causes performance differences between dominant and nondominant hands in lateralized individuals—or, functional motor complementarity.
- The left hemisphere of brain specializes in sequential processing while the right in parallel processing.
- Todor and Doane's theory suggests that "the performance of the nondominant hand mirrors the functional capacity of the contralateral right hemisphere"
- Meaning that, right-handers will have a right-hand advantage for tasks requiring predominantly feedback control and a left-hand advantage for tasks requiring parallel processing.
- Touchless input (device-less) lacks haptic feedback and relies on visual feedback and proprioception.
- Hence, we argue touchless input demands more parallel processing than feedback control and would offer a left-hand performance advantage for right-handers when compared with other input types (e.g., mouse) demanding greater feedback control.
- **Hypothesis**: Touchless input will produce smaller performance differences between left and right hands than a mouse or stylus.

Feedback control or **sequential processing** — actions where feedback is processed to make corrective alterations; closed-loop

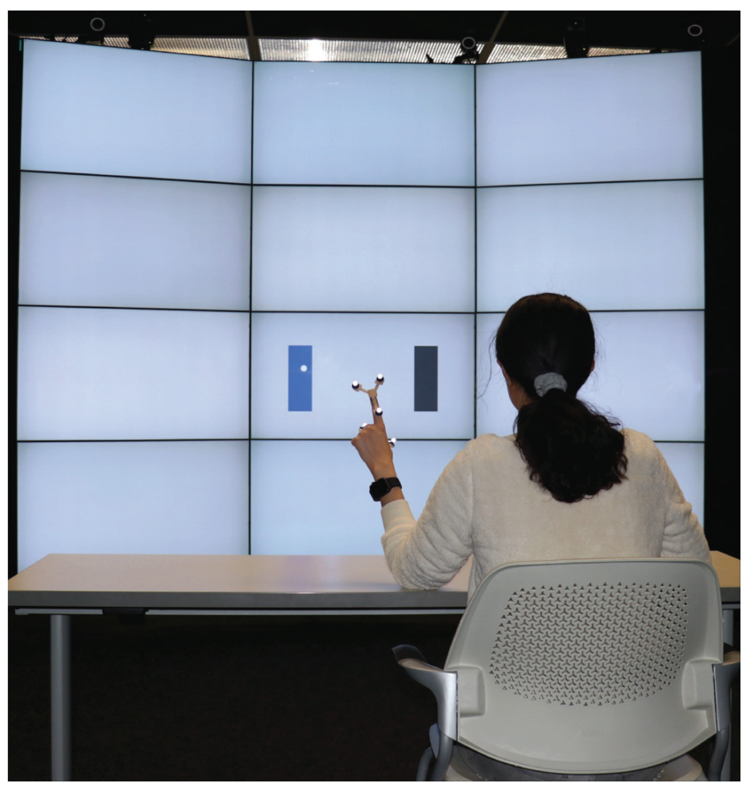
Preprogramming or **programmed control** or **parallel processing** — actions where a set of muscle commands are structured before a movement sequence begins allowing the entire sequence to be carried out uninfluenced by peripheral feedback; open-loop

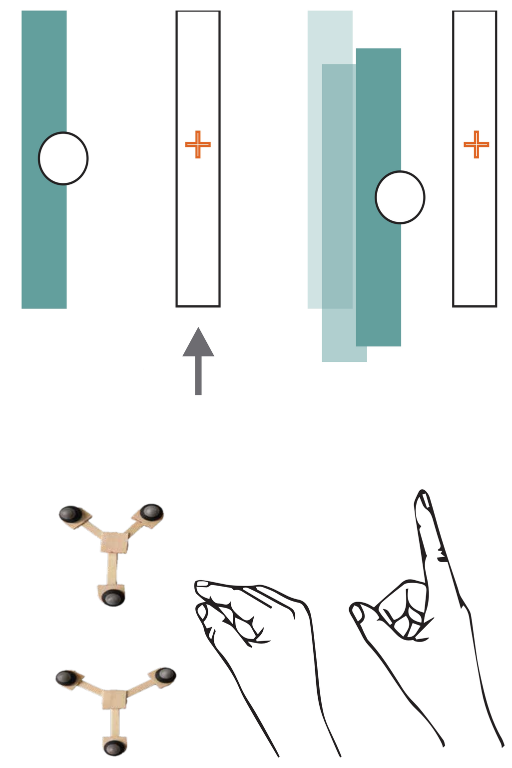


Relative demand for feedback control or sequential processing

With all other conditions being equal, input types demanding more feedback control will have greater degradation between hands in lateralized users.

Methods

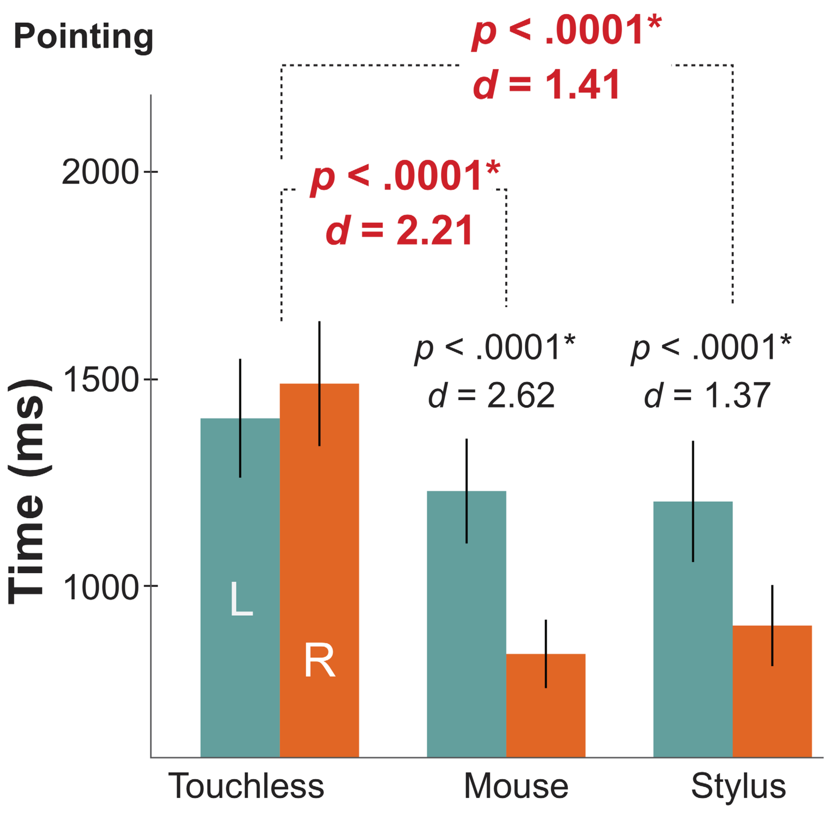


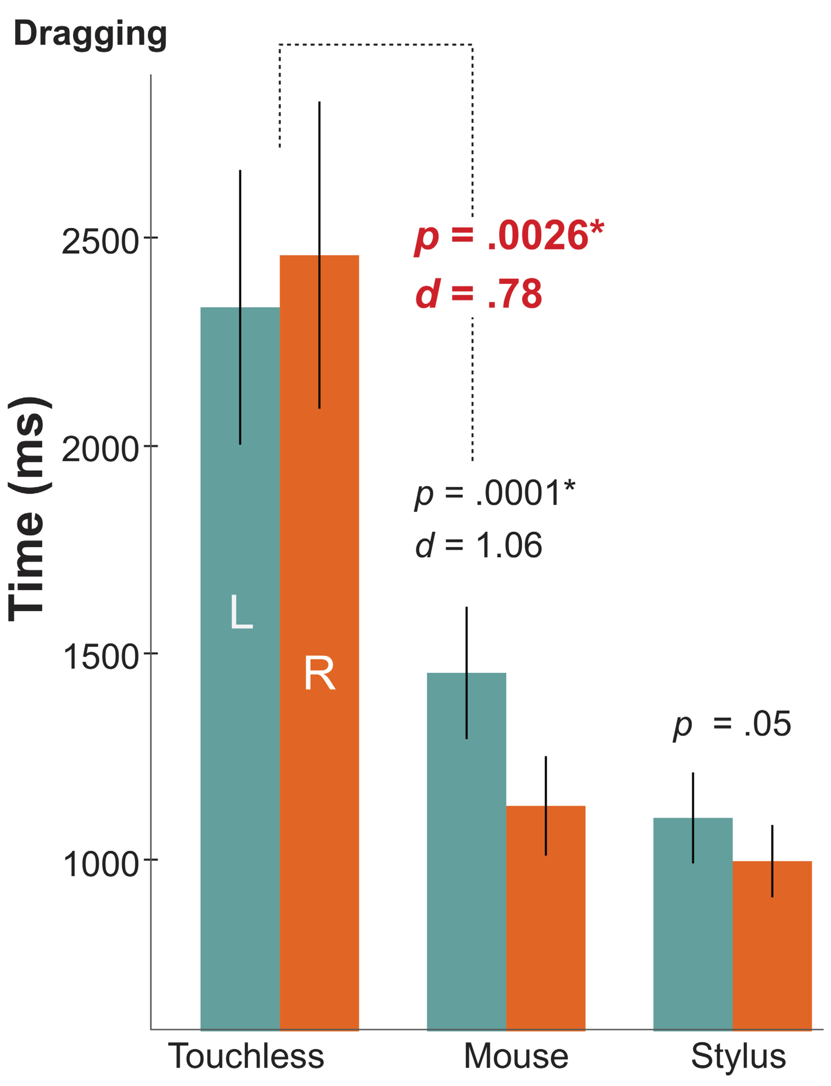


- 20 right-handed participants performed Fitts's one-dimensional (1D) reciprocal pointing and dragging task using their left and right hands.
- A within-subject design was followed.
- **Independent variables**: Input type (mouse, stylus, touchless)
  Task (pointing and dragging)
  Hand (right and left)
- **Dependent variables**: Movement time (MT)
  Error rate
  Throughput (TP)
  Effective Width (W_e)
- Our touchless gesture recognition algorithm (pinch gesture) used marker-based tracking—passive infra-red markers and a VICON motion capture system.
- Experiments were conducted on two days, at least one day apart, with each participant using one hand a day.
- The order of hands, input types, and amplitude-width combinations were randomized, and tasks were counterbalanced using a Latin Square.

Results

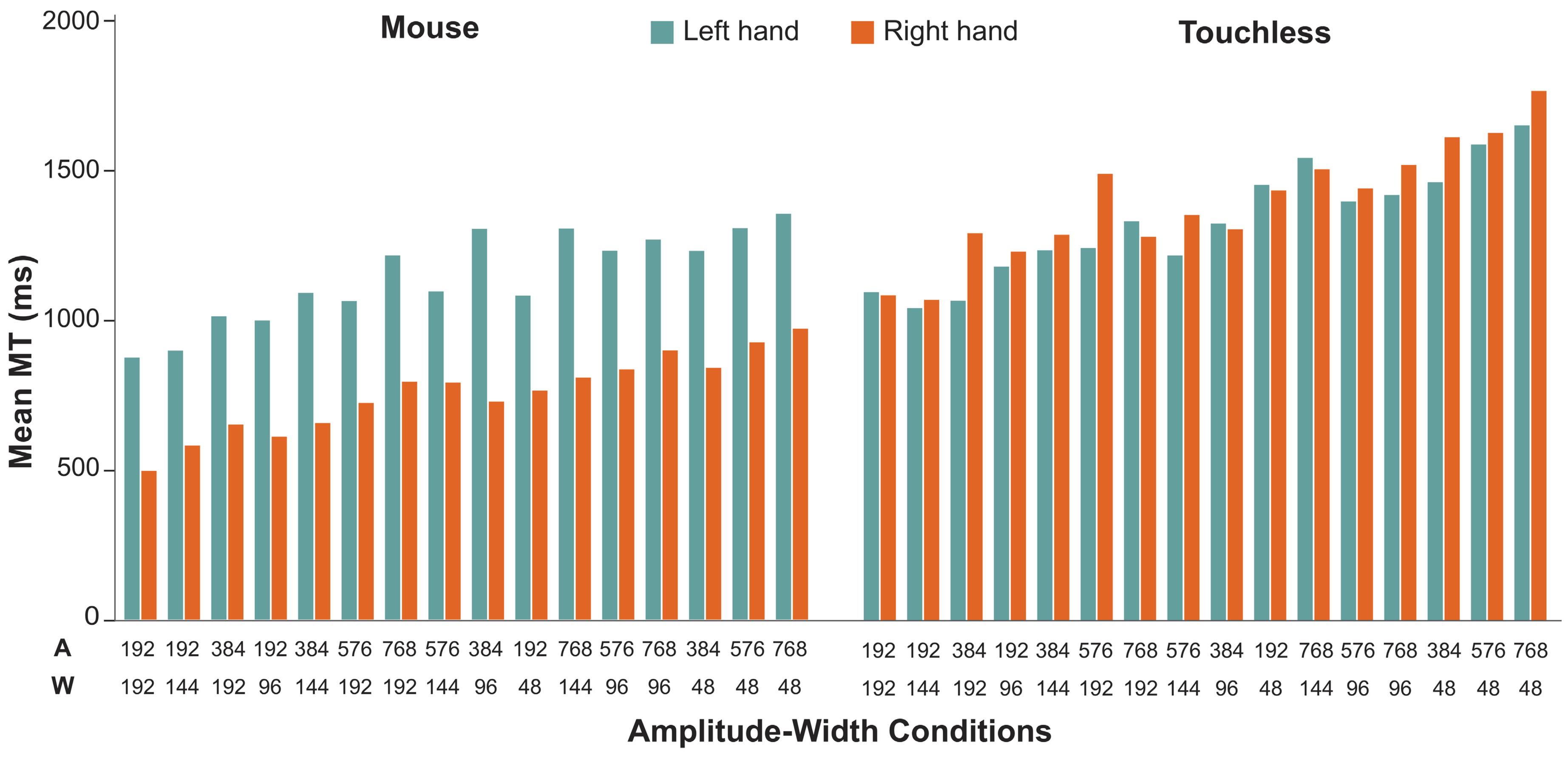
- Results do not suggest an overall advantage for touchless input when using nondominant hand over other device-based input techniques in pointing and dragging tasks.
- But both hands performed almost the same with touchless input—which can inform design decisions for bimanual or multimodal interaction techniques.



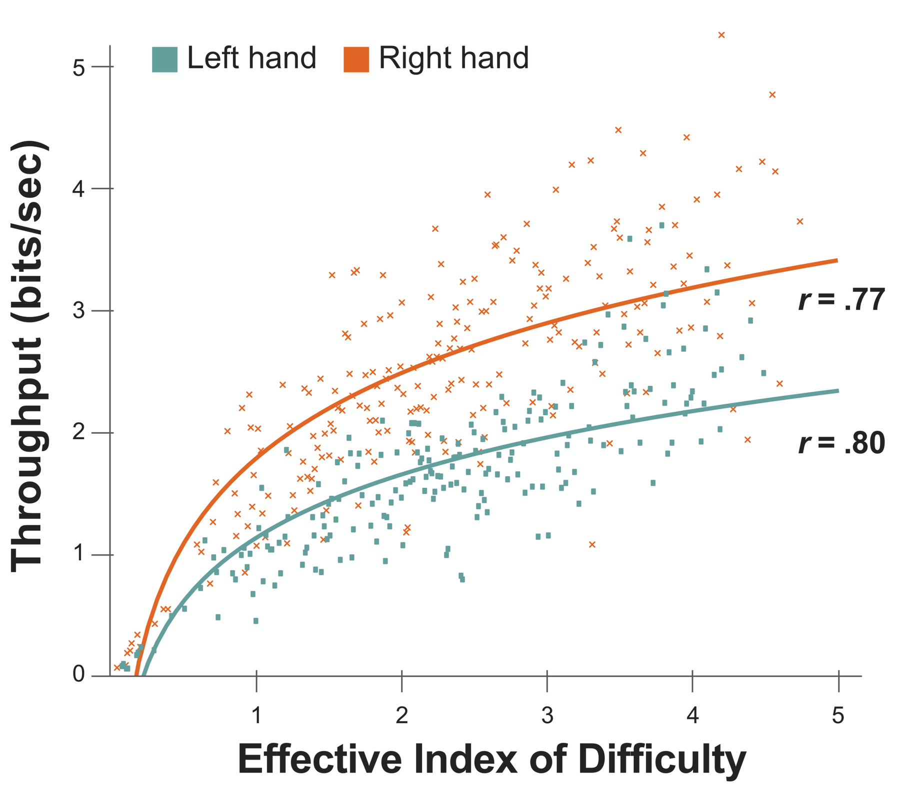


Input Modality

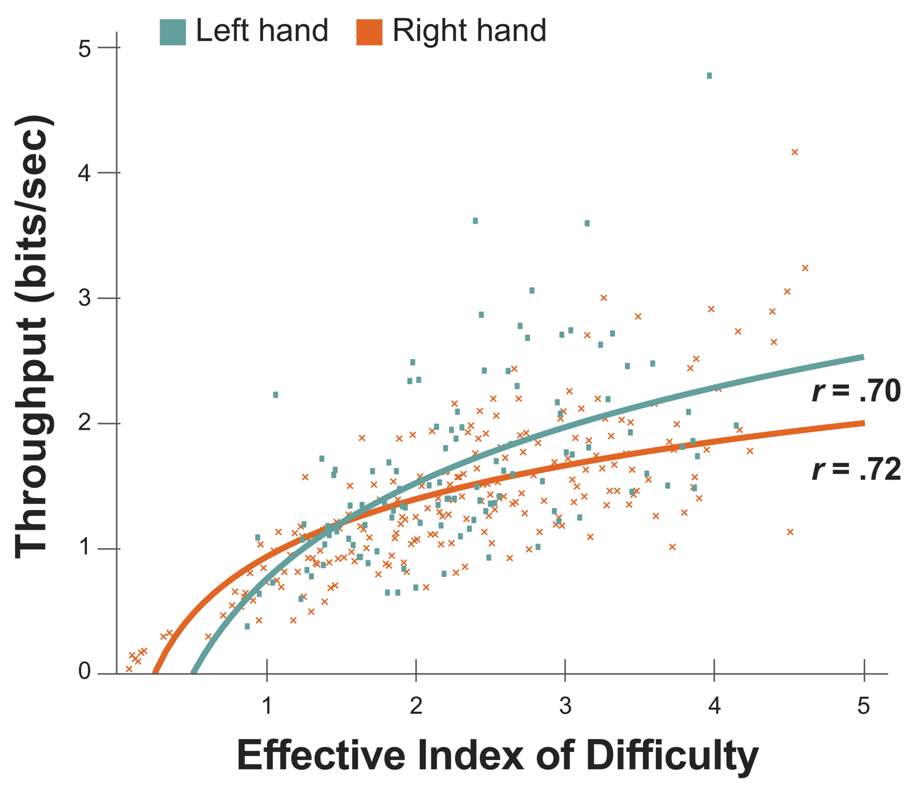
- For pointing, we found significant differences between left and right hand MTs in mouse and styus input but not touchless.
- Planned comparisons found significant between-hand differences between (1) mouse and touchless input, and (2) stylus and touchless input.
- For dragging, we found significant differences between left and right hand MTs in mouse input but not touchless.
- Planned comparisons found significant between-hand differences between (1) mouse and touchless input.



Note the right-hand advantage for mouse and how it disappears for touchless input. Touchless performance in the nondominant hand was almost similar to the dominant hand in the pointing task



Mouse pointing performance.



Touchless pointing performance.

References

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