

A Left-Hand Advantage Motor Asymmetry in Touchless Input

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Motivation

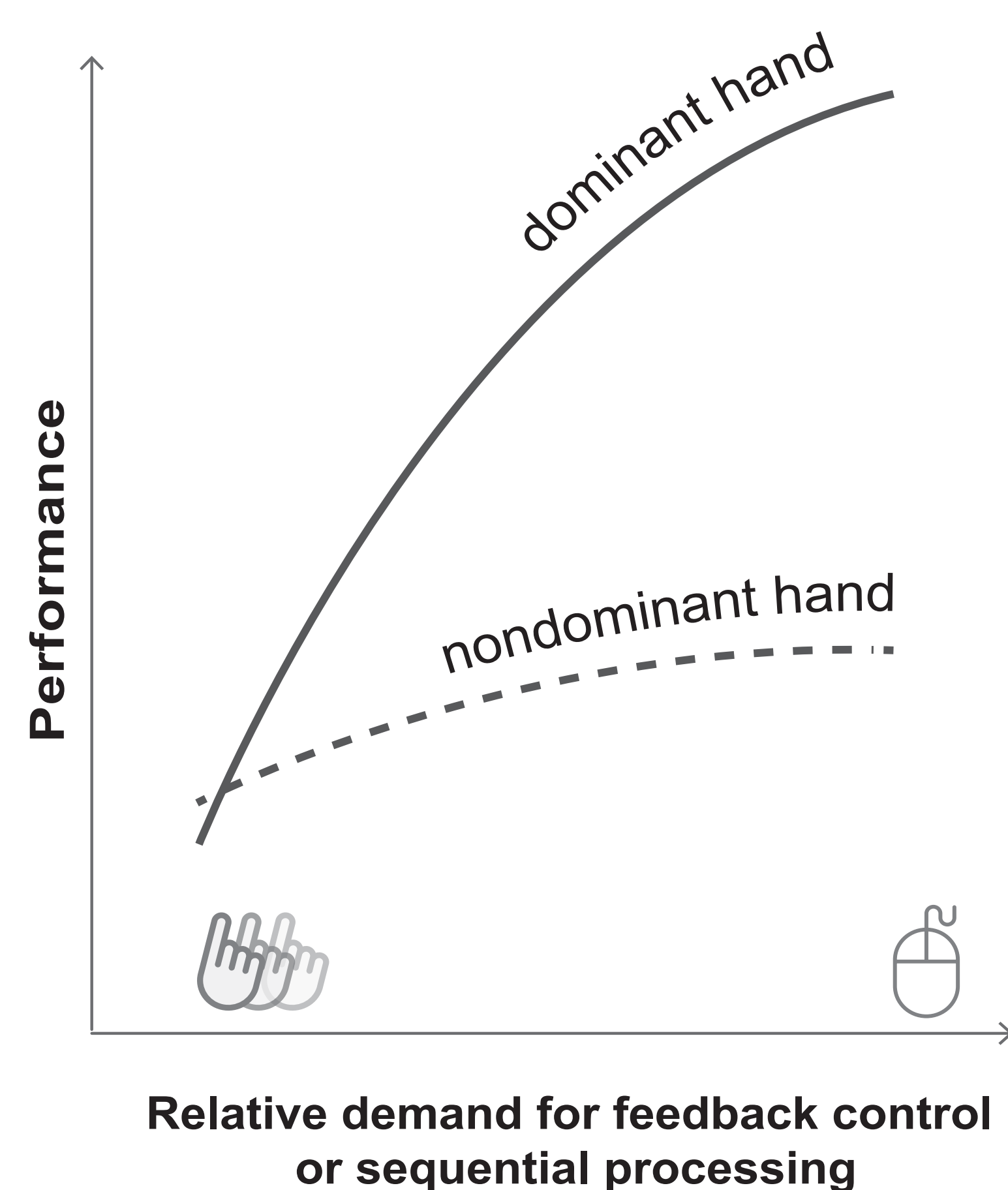
- Touchless gesture is a common input type when interacting with large displays or VR/AR applications. In touchless input, users may alternate between hands or use bimanual gestures.
- User performance in nondominant (or non-preferred) hands when using different input devices has been studied in the 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

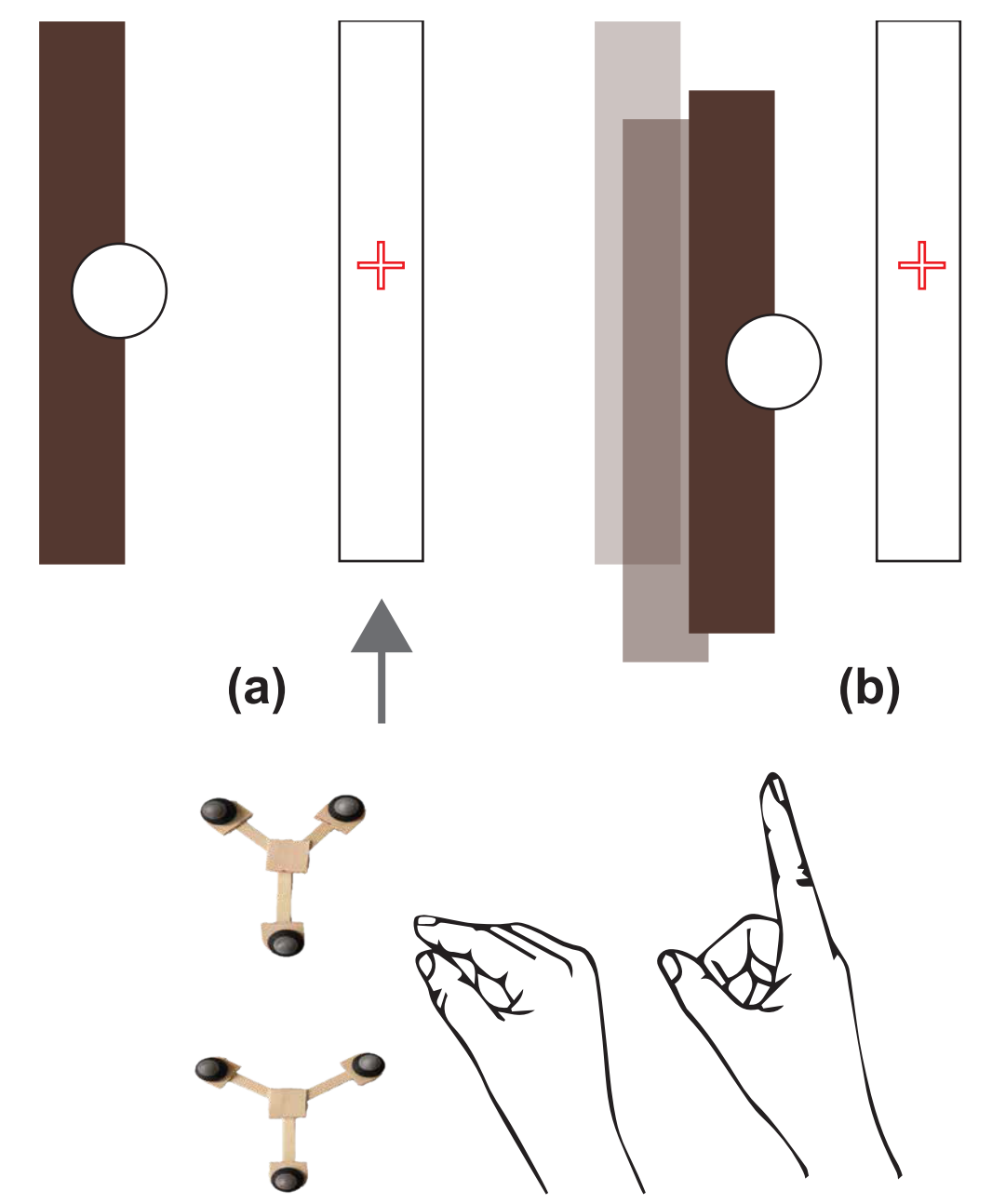
Preprogramming or programmed control or parallel processing

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



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

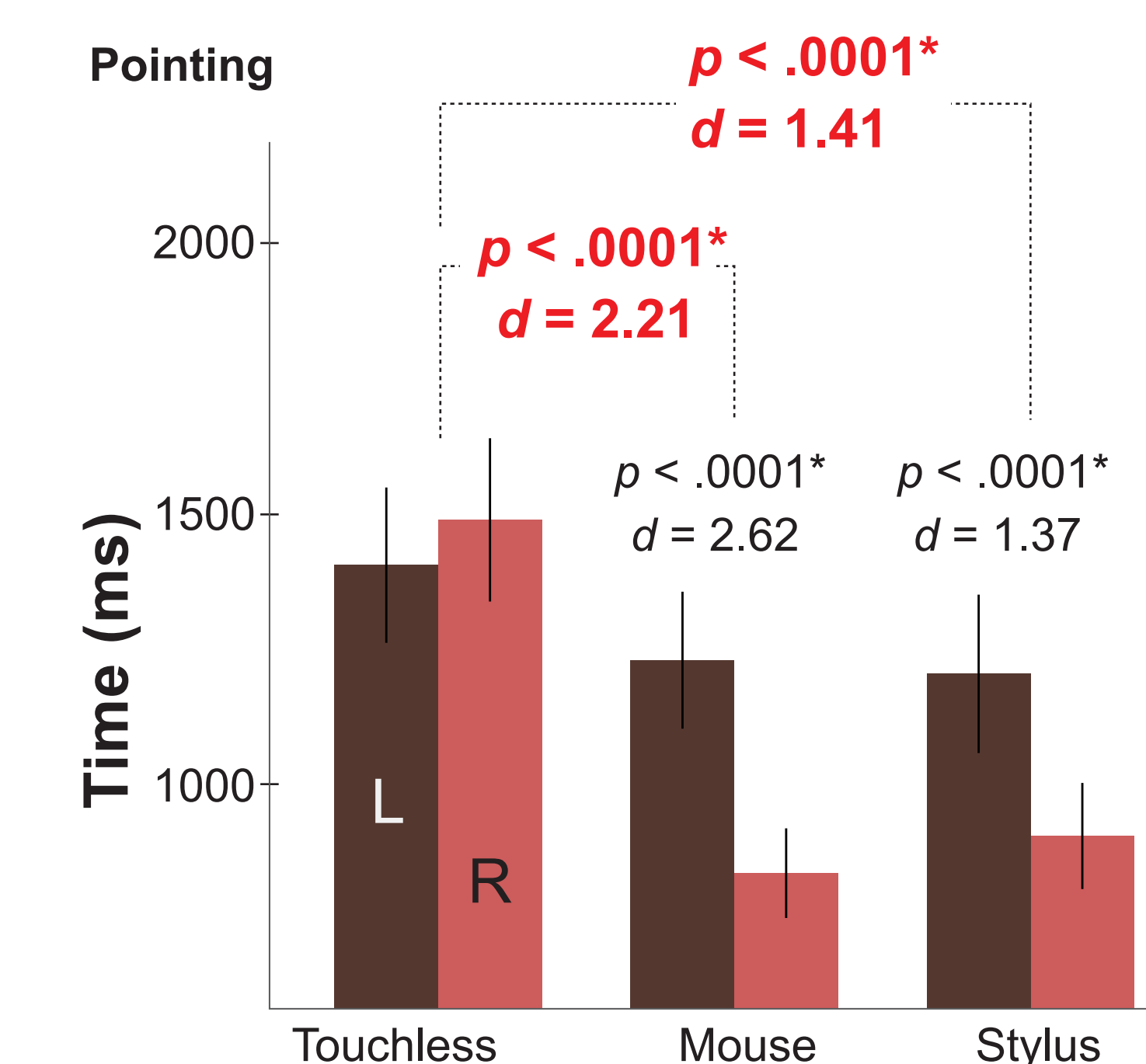
Methods



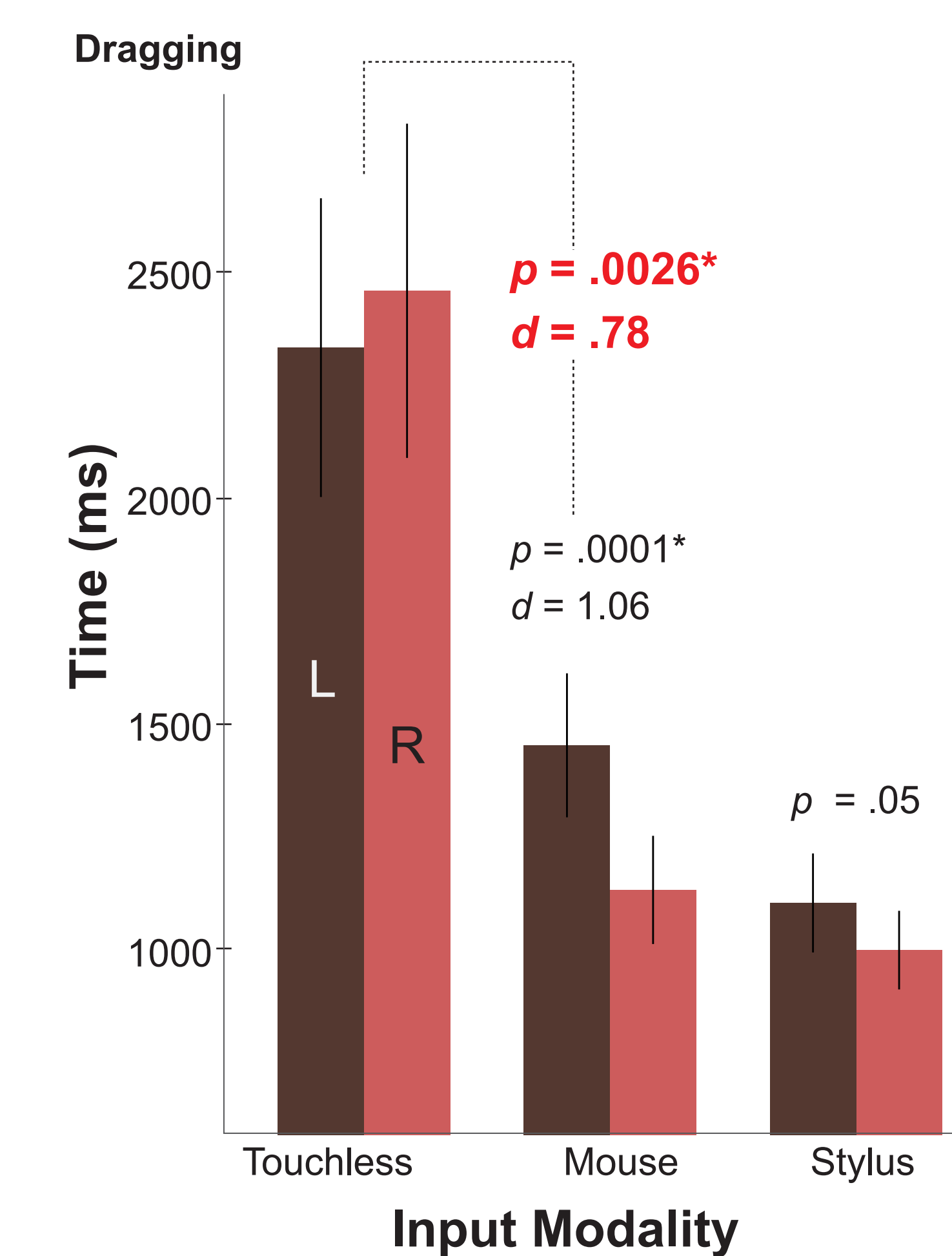
- 20 right-handed participants performed Fitts's one-dimensional (1D) reciprocal pointing and dragging task using their left and right hands.
- A within-subject design was followed.
- **Independent variables:** Input type (mouse, stylus, touchless)
Task (pointing and dragging)
Hand (right and left)
- **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

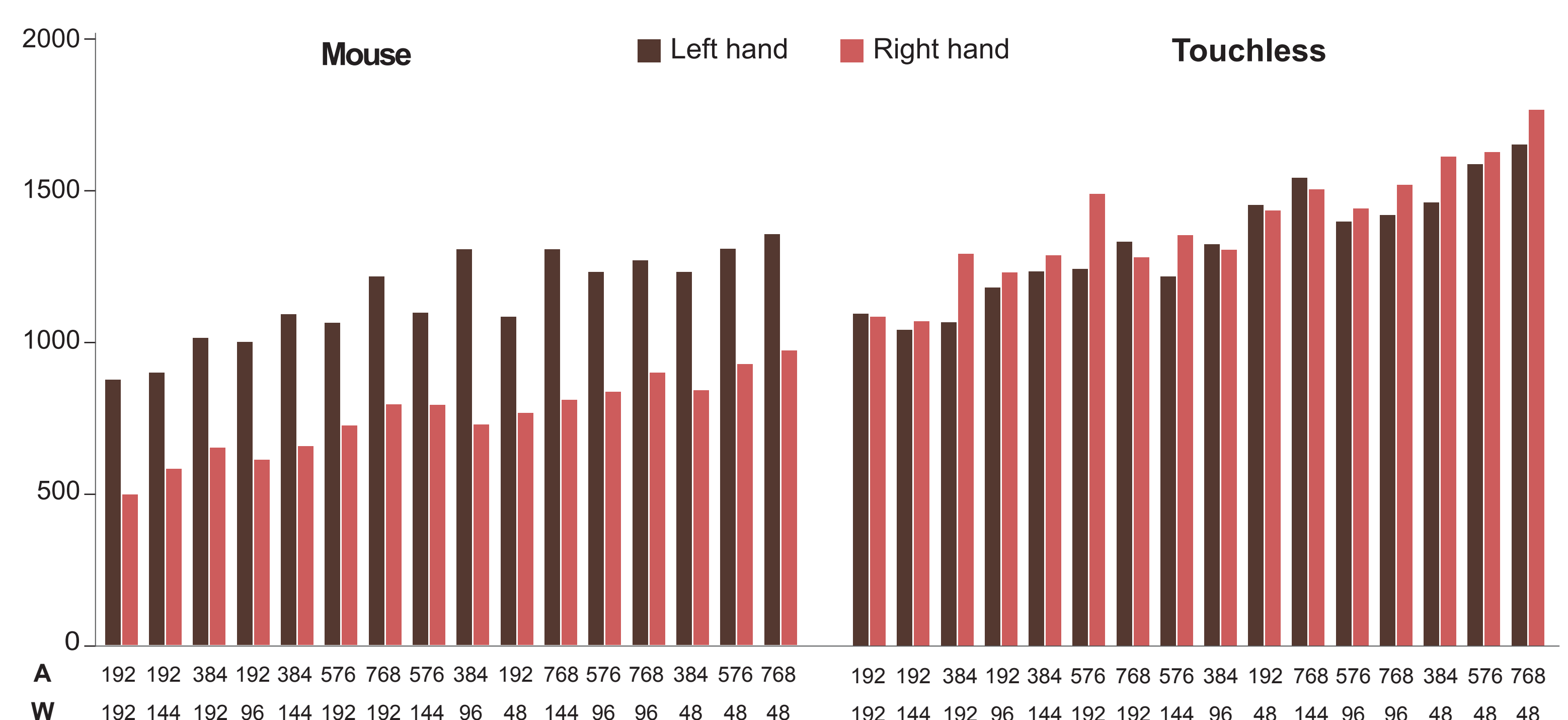
- Results do not suggest an overall advantage for touchless input when using nondominant hand over other device-based input techniques in pointing and dragging tasks.
- But both hands performed almost the same with touchless input—which can inform design decisions for bimanual or multimodal interaction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



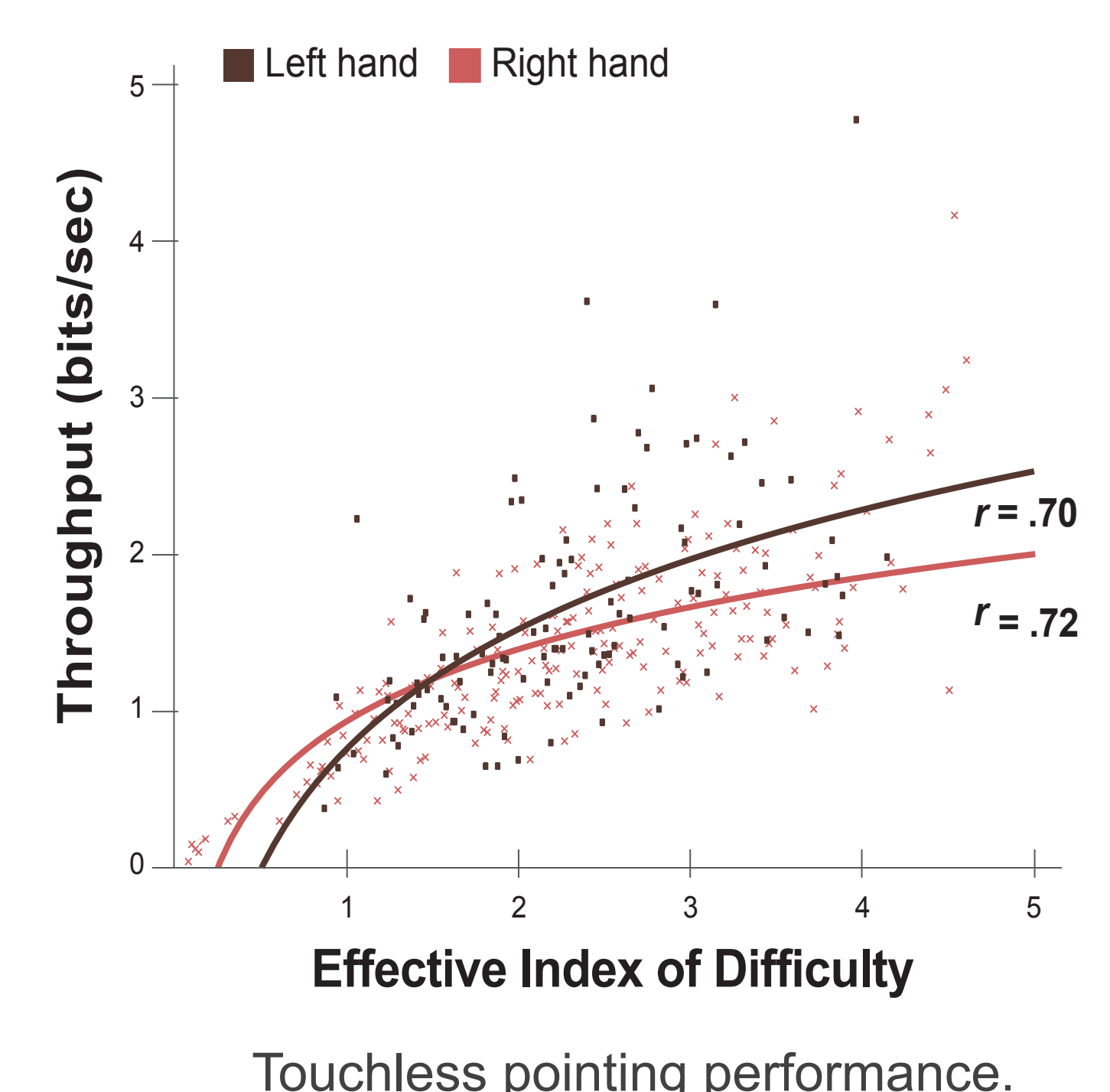
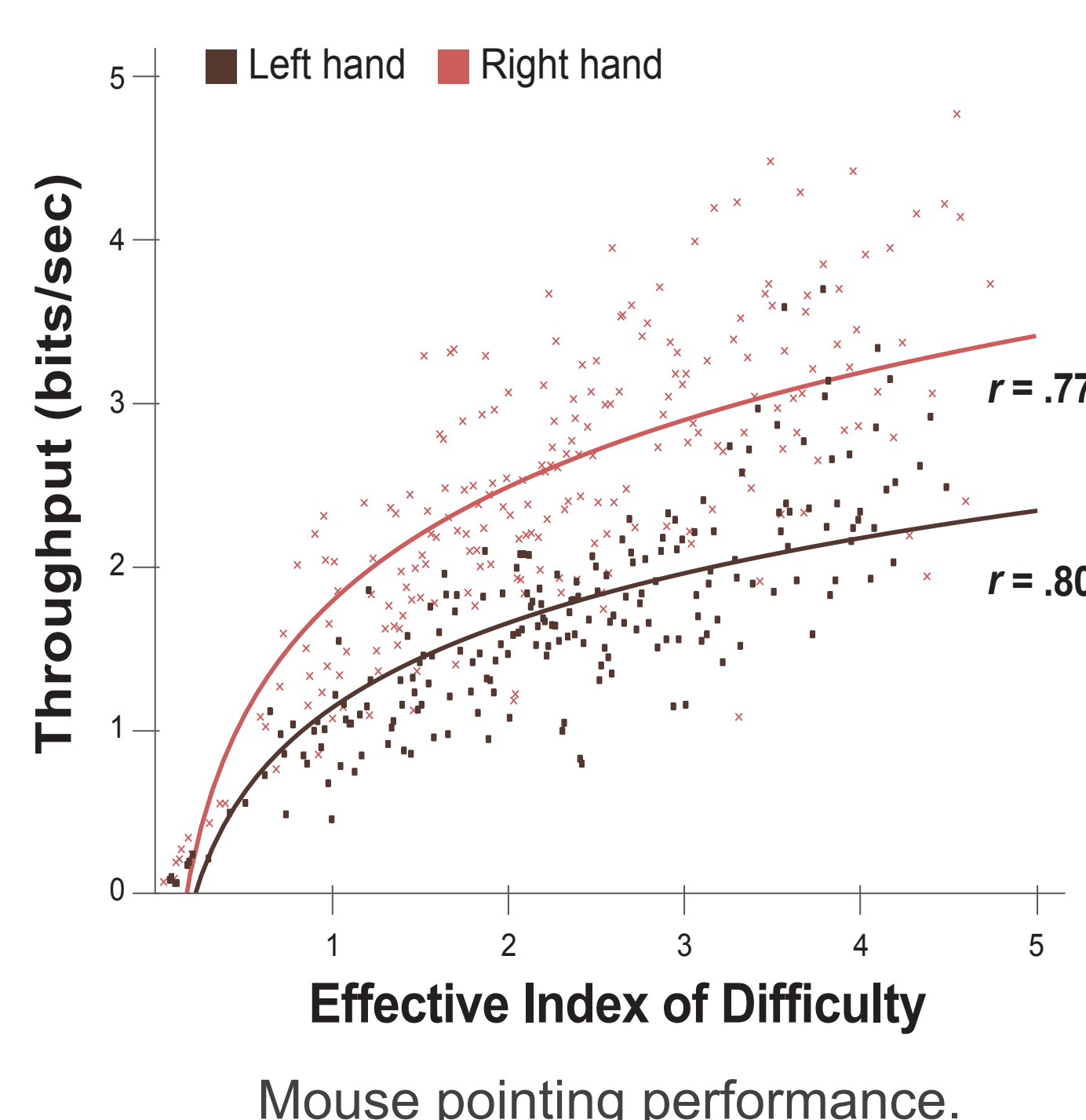
- For pointing, we found significant differences between left and right hand MTs in mouse and stylus input but not touchless.
- Planned comparisons found significant between-hand differences between (1) mouse and touchless input, and (2) stylus and touchless input.



- 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



References

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- Paul Kabbash, I Scott MacKenzie, and William Buxton. 1993. Human performance using computer input devices in the preferred and non-preferred hands. In *Proceedings of the INTERACT'93 and CHI'93 Conference on Human Factors in Computing Systems*. ACM, 474–481.
- John I Todor and Thomas Doane. 1978. Handedness and hemispheric asymmetry in the control of movements. *Journal of Motor Behavior* 10, 4 (1978), 295–300.