

Comparing Eyes-Off-Road Behavior Between Tactile and Touchscreen Secondary Task Interfaces

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Background

- Automakers increasingly put vehicle controls on touchscreens (Huo et al., 2024; Suh & Ferris, 2019), which can cause more distraction than physical buttons and knobs (Nagy et al., 2023).
- This distraction is a safety risk: operating in-vehicle systems accounts for an estimated 1.66% of crashes (Ziakopoulos et al., 2019), and in naturalistic driving, interacting with in-vehicle devices other than the radio or climate controls, such as touchscreen menus, raised crash odds 4.6-fold (Dingus et al., 2016).
- Guidelines recommend single glances under 2 s and limited total eyes-off-road time (NHTSA, 2013), and Euro NCAP’s 2026 protocols reward physical buttons for common functions (Euro NCAP, 2025).
- Rotary controls have been found to be better than touchscreens for continuous adjustments and list scrolling (Rydström et al., 2012; Zhang et al., 2017), and haptic feedback can reduce the need to look away (Grane & Bengtsson, 2013).
- Total eyes-off-road time is a common distraction metric (Purucker et al., 2017), and drivers shorten touchscreen glances as driving demand rises (Ebel et al., 2023); less is known about when the eyes return, relative to the input, on physical versus touchscreen controls.

Questions

Q1

How often and how long do drivers look away?

Q2

Which controls have the biggest difference between tactile and touchscreen inputs?

Q3

Does primary task performance differ between interfaces during secondary task events?

Q4

When do the eyes return to the primary task, relative to the input, between interfaces?

Method

- 18 adults (10 F, 8 M; M age = 25); within-subjects, order counterbalanced.
- Steer to track a target on a scrolling path; 120 numbered prompts per 15-min drive, each ending at the first correct input.
- Controls (tactile vs. touchscreen):** button vs. button; switch (latching button) vs. toggle; dial (rotary encoder) vs. scroll bar; knob (potentiometer) vs. slider (Fig. 1).
- Pupil Labs Core eye tracker (60 Hz; Kassner et al., 2014); off-road glances parsed following ISO 15007 (< 100 ms excluded). 4,080 interactions, 3,680 glances.
- Mixed-effects models with random intercepts and modality slopes by participant.



Fig. 1. (A) Tracking task; (B) tactile and (C) touchscreen panels, matched in control type, size, and placement (12"). 1 = knob / slider; 2–3 = buttons; 4–6 = dial / scroll bar; 7–8 = switch / toggle.

1 Touchscreens nearly always drew a glance

97%
2.3×

- of touchscreen interactions included an off-road glance, vs. 57% for tactile (Fig. 2)
- more eyes-off-road time per interaction (tactile 0.35 s vs. touchscreen 0.81 s)
- Model-estimated glance probability: tactile 58% vs. touchscreen 99% ($b = 4.22$, $p < .001$).
 - Touchscreen glances were longer (tactile 0.53 s vs. touchscreen 0.70 s, $p < .001$; Fig. 3), and more interactions needed 2 or more glances (tactile 6% vs. touchscreen 14%, $p < .001$; Fig. 2).

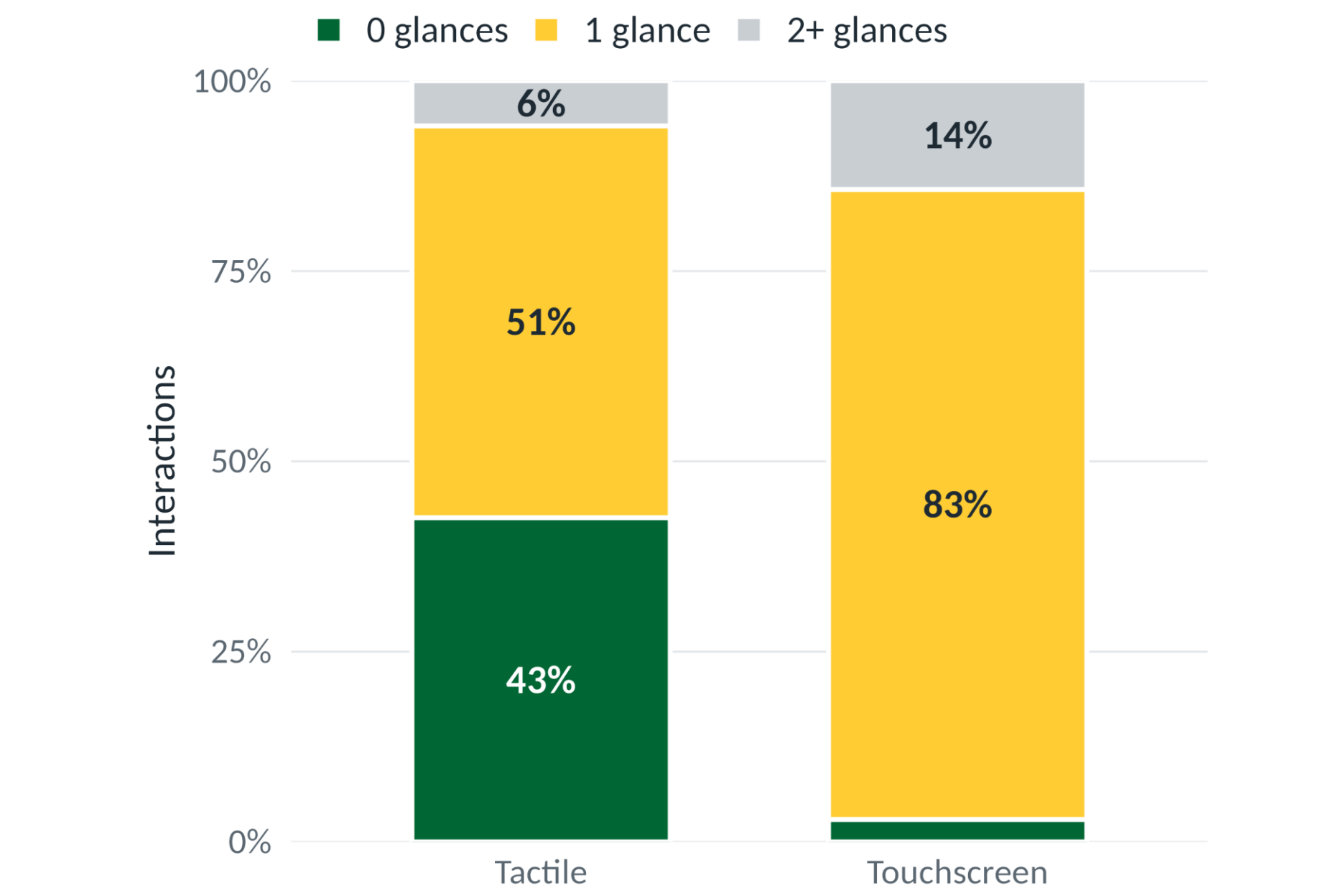


Fig. 2. Glances per interaction.

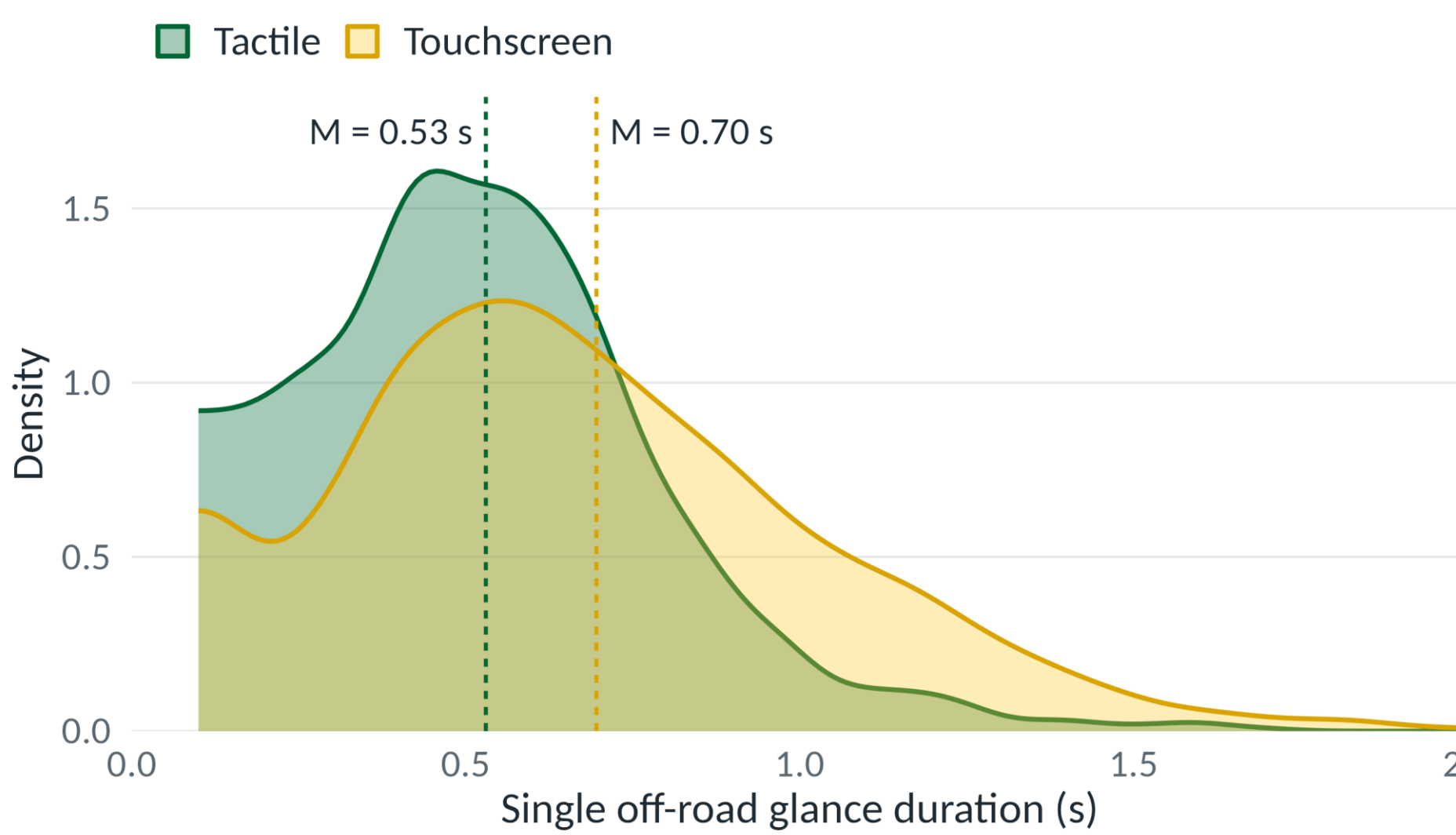


Fig. 3. Single-glance durations; dashed lines = means; glances ≥ 100 ms.

2 Controls varied in glance requirement

- The tactile knob was used eyes-free 72% of the time vs. 5% for its touchscreen twin, the slider (Fig. 4).
- Touchscreen raised eyes-off-road time most for the continuous controls (dial / scroll bar, knob / slider; $b = 0.080$, $p < .001$; Fig. 4).

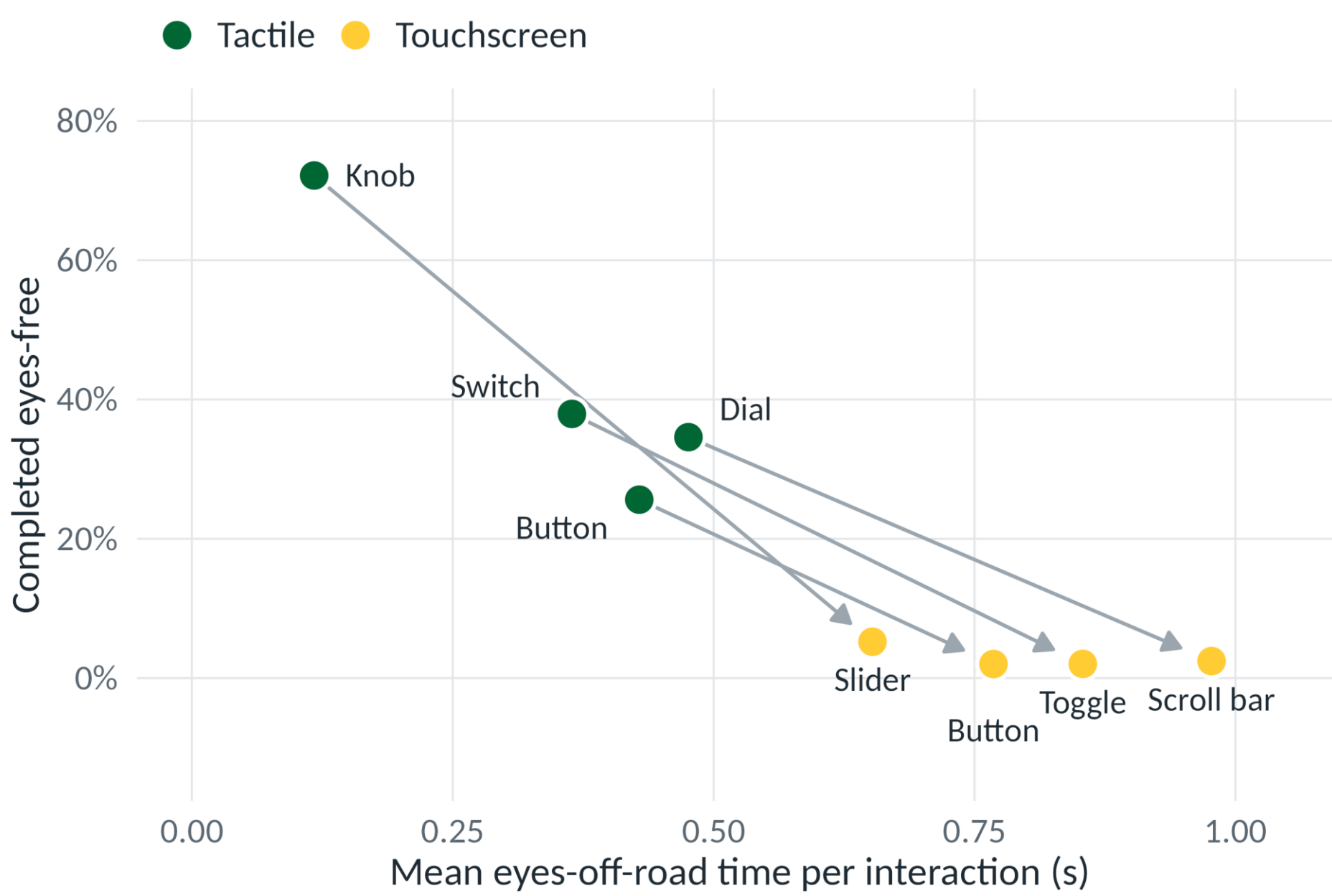


Fig. 4. Each arrow runs from a tactile control to its touchscreen twin.

3 Tracking error did not differ

In the 4 s after each prompt, lateral and longitudinal tracking error did not differ between tactile and touchscreen controls (paired t-tests on participant means; lateral: $p = .19$; longitudinal: $p = .60$; Fig. 5).

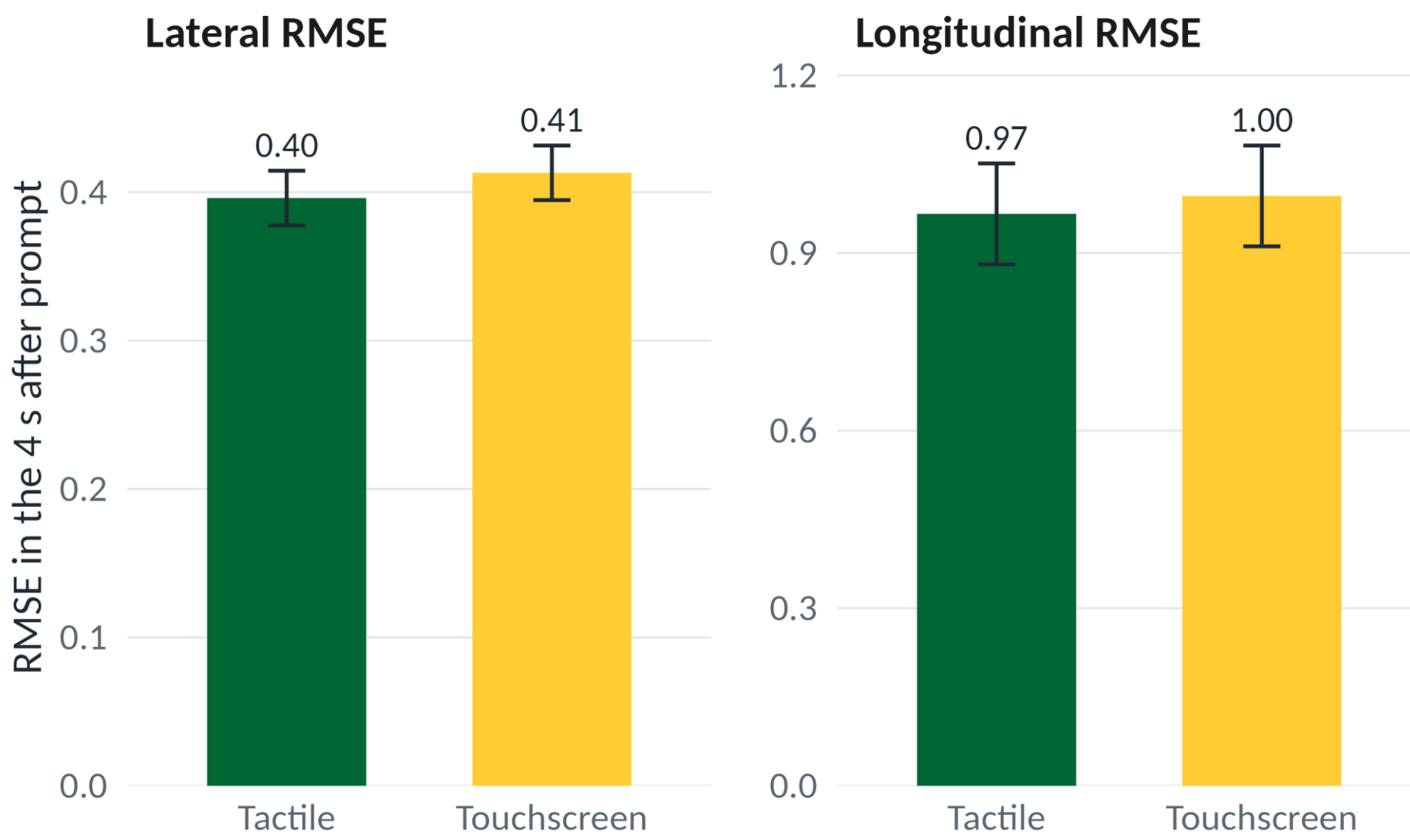


Fig. 5. Tracking RMSE in the 4 s after prompt onset; error bars = within-subject 95% CIs.

4 Tactile controls: look once, then finish by feel

- Both interfaces started the same way: the first glance came ~0.65 s after the prompt (median; Fig. 6).
- Eyes were back on the road before the input registered in 91% of glanced tactile interactions vs. 55% on touchscreen ($b = -2.14$, $p < .001$; Fig. 7), though rates differed by control.
- Last glance ended before the input by 0.39 s on tactile vs. 0.03 s on touchscreen ($b = 0.36$, $p < .001$; Fig. 8).

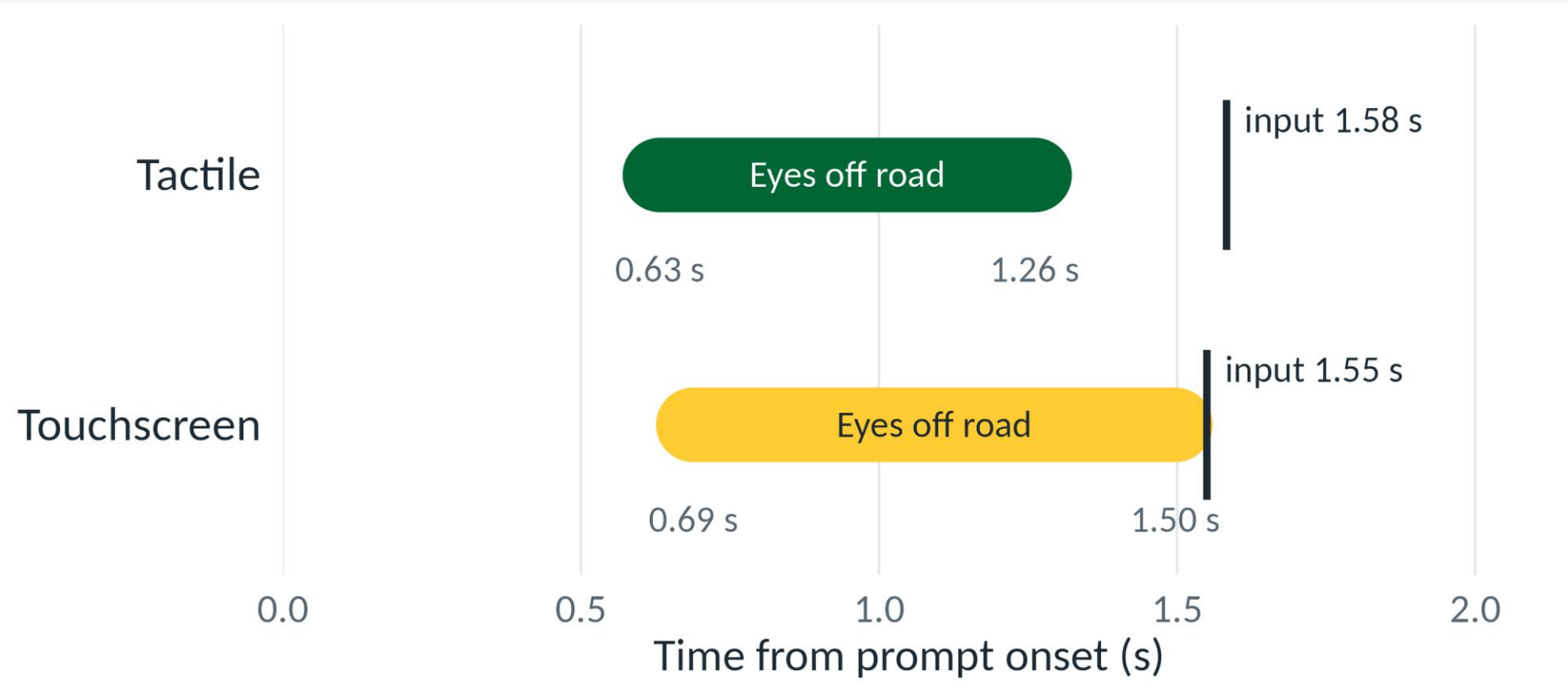


Fig. 6. A typical glanced interaction (median times). Black line = input registered.

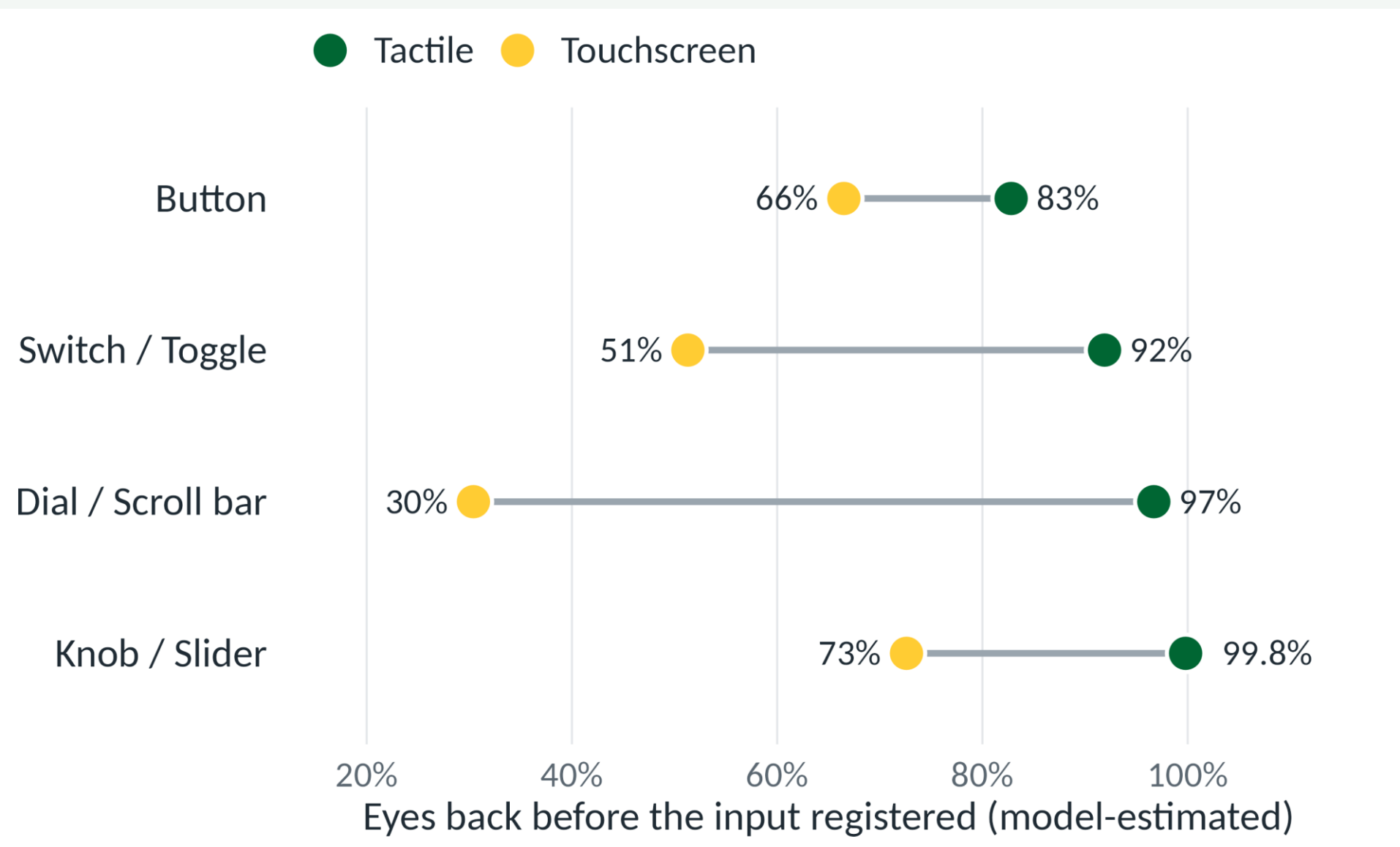


Fig. 7. Model-estimated; modality $\times$ control $\chi^2(3) = 125.9$, $p < .001$. The scroll bar was watched to the end most often.

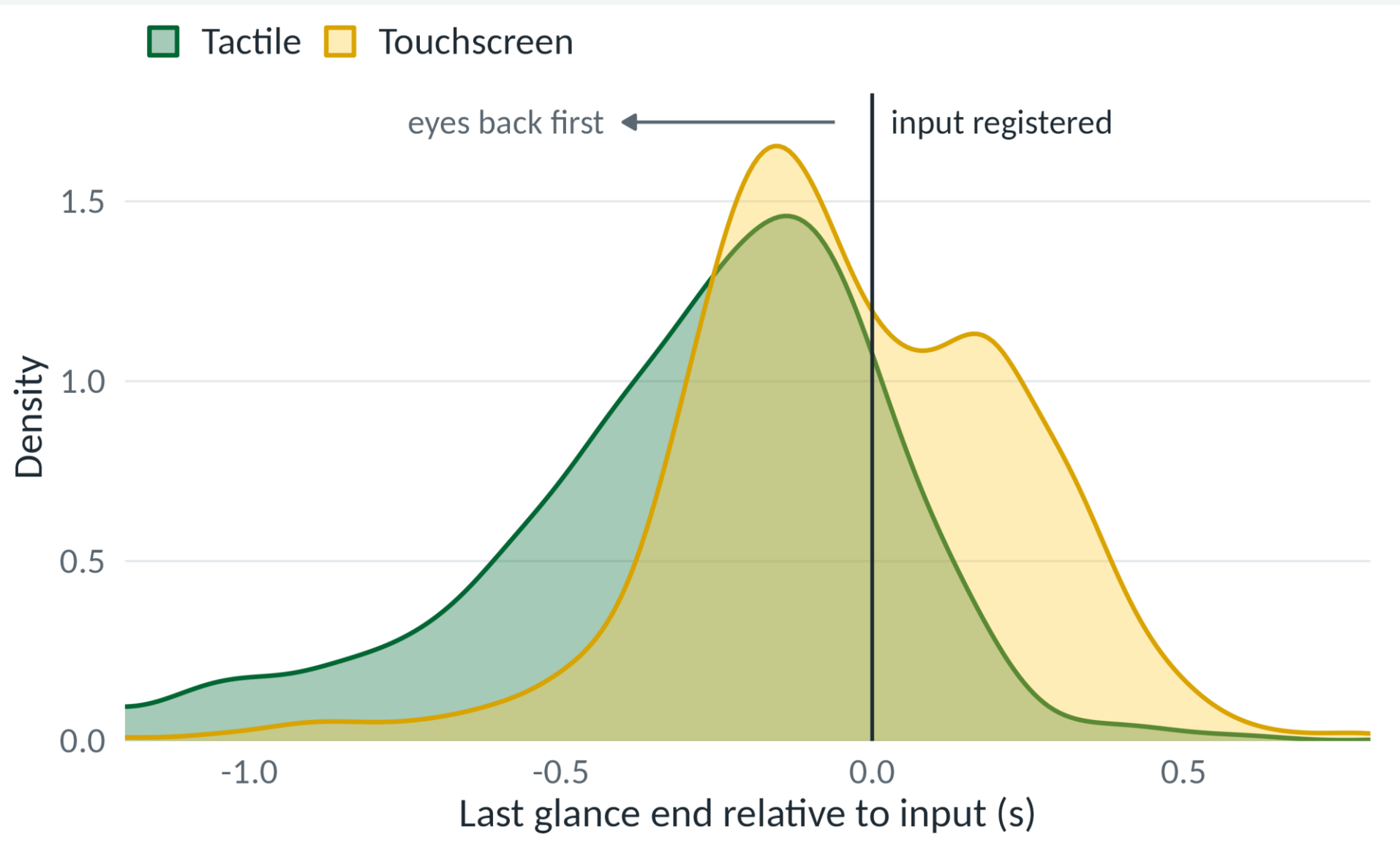


Fig. 8. When the last glance ended, relative to the input.

Takeaways

1.

Touchscreens made an off-road glance nearly unavoidable, and those glances were longer.

2.

The gap was largest for continuous controls; the tactile knob was the most eyes-free.

3.

Tracking error did not differ between interfaces despite the glance differences.

4.

Tactile controls let drivers look once and finish by feel; touchscreens often held the eyes until the input registered.

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