

When Buttons Disappear: Trust and Safety in Touchscreen-Dominated Vehicle Systems

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Abstract

This study investigates how automotive modality influences drivers' trust in vehicle interfaces, with a distinction between cognitive trust (perceived reliability and predictability) and affective trust (perceived safety, confidence, and comfort). While prior research has focused primarily on objective usability metrics such as task completion time and visual demand, less attention has been given to subjective trust perceptions in safety-critical driving contexts. To address this gap, a within-subject survey study ($N = 32$) was conducted in which participants evaluated both physical controls and touchscreen-based controls using a 7-point Likert scale. Results indicate that physical controls are associated with higher levels of both cognitive and affective trust compared to touchscreen interfaces ($p < .001$), with large effect sizes observed across both constructs. Qualitative responses further reveal that touchscreens are perceived as requiring greater visual attention, lacking reliable feedback, and introducing interaction uncertainty, whereas physical controls support eyes-free interaction and consistent operation. Findings suggest a persistent expectation gap between touchscreen interface design and user needs in driving environments. These results highlight the importance of incorporating tactile feedback, predictability, and low-demand interaction mechanisms in the design of automotive human-machine interfaces.

1 Introduction

Modern vehicle interiors are undergoing a stark transformation from physical controls to touchscreen-based interfaces. Approximately 98% of all new vehicles now include an in-vehicle display, and these screens increasingly mediate interactions that were once handled through tactile inputs [5]. The reasons often include mentions of cost effectiveness, aesthetics and software flexibility [4]. This transition reflects broader digitalization trends and aesthetic minimalism within vehicle interiors [4]. Automotive cockpit design choices have direct safety implications. The input type can impact driver attention, workload and overall safety.

Empirical research has demonstrated measurable performance differences between touchscreen and physical control modalities. Touchscreen interaction has been associated with longer glance durations and higher visual demand compared to traditional tactile controls [6]. Research on tactile feedback in steering wheel controls highlights the importance of haptic confirmation for reducing subjective task difficulty and supporting effective interaction [2]. Euro NCAP has also introduced updated safety criteria encouraging physical controls for key functions to reduce distraction [3]. Studies on control discoverability further show that deviations from established interface conventions can increase search time and error rates [7].

While these studies provide important performance-based insights, they primarily focus on objective usability measures such as task completion time, error rate, and visual workload. Far less attention has been given to how drivers subjectively evaluate the reliability, predictability, and safety of different control modalities. This distinction is important because usability performance does not necessarily translate directly into perceived trust.

Consumer and preference research has shown strong favorability toward physical controls in many driving contexts [6]. Preference alone does not explain why drivers may feel safer or more confident using one control type over another. Preference reflects general liking or familiarity, whereas trust reflects a willingness to rely on a system under conditions of uncertainty and divided attention.

In automotive environments, where drivers must continuously manage primary (vehicle control) and secondary (interface interaction) tasks, trust plays a critical role. Cognitive load theory suggests that secondary task demands compete for limited attentional resources [8]. If an interface increases visual demand or unpredictability, drivers may experience heightened cognitive strain, potentially influencing their perceived safety and confidence.

In automotive HCI research, control type is most often evaluated through performance-based metrics such as visual demand, task completion time, and error rates [2, 6]. These measures may provide important safety insights, but the understanding of how drivers interpret interface reliability during interaction is limited. Affective computing research shows that emotional and perceptual states significantly influence driver behavior and safety outcomes [1].

In this study, trust is conceptualized as a multidimensional construct consisting of:

Cognitive trust: Perceived reliability, predictability, and consistency of the control system.

Affective trust: Feelings of safety, confidence, and comfort during interaction.

Driving requires sustained attentional engagement. According to cognitive load theory, additional visual or manual demands can impair task management [8]. Touchscreen interfaces have been associated with higher visual demand and longer off-road glances compared to tactile controls [6].

Beyond objective workload, affective responses to interface interaction may influence perceived safety. Research in affective automotive user interfaces demonstrates that emotional states significantly impact driving behavior and perceived risk [1]. If a control modality increases uncertainty or workload, drivers may experience reduced confidence or comfort, influencing affective trust.

Based on this theoretical framework, this study examines the relationship between control modality and multidimensional trust using the following research questions:

RQ1: How does control modality (physical controls vs. touchscreen interfaces) influence drivers' cognitive trust, defined as perceived reliability and predictability of in-vehicle systems?

RQ2: How does control modality influence drivers' affective trust, defined as perceived safety, confidence, and comfort during interaction?

By separating cognitive and affective components of trust, this work moves beyond performance metrics and preference data to examine how interface design shapes psychological reliance in safety-critical contexts.

2 Literature Review

2.1 Control Modality and Cognitive Trust

Cognitive trust refers to drivers' evaluations of system reliability, predictability, and consistency during interaction. In automation contexts, predictability is closely tied to control discoverability and stable interaction mapping.

Robertson and Cox [2024], demonstrate that when control location or type deviates from established conventions, search time significantly increases (4.24s vs. 9.83s, $p < 0.001$). Increased search duration reflects reduced immediate discoverability and suggests that deviations from expected spatial mappings disrupt drivers' mental models [7]. Because perceived reliability depends on consistent system behavior, reduced discoverability may influence cognitive trust in control systems.

Similarly, touchscreen performance varies by technology and implementation. Pitts et al. [2014], compared resistive, capacitive, and infrared touchscreen systems in a driving simulator and found significant differences in responsiveness and user preference. Capacitive systems demonstrated superior performance compared to resistive screens [6]. These findings indicate that reliability perceptions may depend not only on control type (touch vs physical), but also on technological implementation.

Predictability is further influenced by tactile affordances. Physical controls provide stable spatial placement and mechanical feedback, which can reinforce consistent action-response mappings. Schnelle-Walka and Radomski [2019], note that tactile interaction reduces visual demand relative to purely graphical interfaces, supporting interaction stability. Although these studies focus primarily on usability outcomes, stable tactile cues may contribute to drivers' perceptions of reliability.

Touchscreen interfaces, particularly when menu-driven or dynamically reconfigurable, may reduce spatial stability [7]. While such flexibility supports design minimalism, it may also introduce variability in control access. Existing research primarily measures search time, error rates, and workload rather than directly assessing perceived reliability and predictability [6, 7, 8].

While prior work establishes performance and discoverability differences between control modalities, fewer studies explicitly examine how these differences translate into drivers' cognitive trust evaluations.

2.2 Control Modality and Affective Trust

Affective trust refers to drivers' perceived safety, confidence, and comfort during interaction under divided attention.

Driving is a safety-critical activity, requiring sustained attentional engagement. Touch-based interfaces often require visual confirmation of input, potentially increasing glance demand and cognitive effort [6]. Pitts et al. [2014], report that touchscreen technologies differ in usability and visual demand. Schnelle-Walka and Radomski [2019], further argue that graphical touch interfaces can increase visual workload compared to multimodal systems incorporating tactile cues.

Feedback modalities have been investigated as a mechanism to mitigate touchscreen limitations. Diwischek and Lisseman [2015] show that vibrotactile feedback for virtual steering wheel switches improves subjective usability and user preference. Participants expressed clear preferences for specific vibration characteristics, suggesting that feedback design influences perceived interaction quality [2].

Puente et al. [2024], found that vibration and audio feedback improved task performance and attention, while force touch offered limited benefit. Stölzle et al. [2025], quantified preferred haptic pulse durations (13-20 ms), indicating that specific feedback characteristics influence perceived interaction satisfaction.

These studies focus on usability, preference, and performance outcomes, but they imply that interaction certainty and confirmation may affect driver confidence [2, 5, 9]. Direct measurement of perceived safety and comfort during touchscreen interaction remains limited.

Emotional and cognitive factors can also shape affective trust. Braun et al. [2021], review affective automotive interfaces and argue that stress, uncertainty, and workload influence safety perceptions. Even when systems function correctly, elevated cognitive demand may alter drivers' subjective sense of security [1].

Collectively, the literature indicates that control modality influences workload, feedback quality, and discoverability. However, the relationship between these factors and drivers' perceived safety, comfort and confidence has not been systematically isolated.

2.3 Research Gap

Existing research demonstrates that control modality affects discoverability and search time, usability and touchscreen performance variability, feedback effectiveness and interaction quality, visual demand and cognitive workload, and emotional and stress-related safety perceptions [1,2,5,6,7,8,9].

These studies predominantly measure objective performance metrics or general preference outcomes. They rarely distinguish between drivers' cognitive evaluations of reliability and predictability and their affective experiences of safety and confidence.

A conceptual gap remains in understanding how control modality influences cognitive trust (perceived reliability and predictability) and affective trust (perceived safety, confidence, and comfort) in automotive interfaces.

3 Method

3.1 Study Design

This study employs a cross-sectional, within-subject survey design where participants evaluated physical and touchscreen-based control modalities. The goal was to investigate how automotive control

modality influences drivers' cognitive and affective trust in safety-critical driving situations. A structured Likert-style questionnaire was selected to quantify subjective perceptions of reliability, predictability, safety, confidence and comfort across control modalities. All participants evaluated both control types, allowing for paired comparison between modalities.

3.2 Participants

Adults with driving experience were selected using convenience sampling methods. Eligibility criteria were limited to driving experience and age. Demographic and contextual variables were collected to support exploratory subgroup comparisons and to filter participants without the necessary eligibility criteria.

Participants were also asked whether their primary vehicle relies mostly on touchscreen control and whether they have prior experience using touchscreen-dominant vehicle interfaces. These variables were collected to assess familiarity effects and potential moderating influences on trust perceptions.

3.3 Survey

The final survey (Appendix 1) consists of 28 items organized into six categories: Consent and Background, Cognitive Trust: Physical Controls, Cognitive Trust: Touchscreen Controls, Affective Trust: Physical Controls, Affective Trust: Touchscreen Controls, Comparative Evaluation, Open-Ended Questions. Section titles were stripped to *Section Number* in the final version to eliminate any bias derived from the sections titles. In the sections after Consent and Background, a 7-point Likert scale, 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree, was used to capture attitudes towards the given statements.

Parallel phrasing was used across control modalities to reduce acquiescence bias and enable direct comparison. Negatively worded items were reverse-coded prior to analysis.

Participants took the survey, through an online link, using a device of their choice and in a setting of their choice, without instruction or influence from a moderator.

3.4 Measures

The survey instrument was designed to measure two dimensions of trust in automotive interface controls: cognitive trust and affective trust. These constructs correspond directly to the research questions of the study. Cognitive trust was defined as drivers' perceived reliability and predictability of in-vehicle control systems, while affective trust was defined as drivers' perceived safety, confidence, and comfort when interacting with vehicle controls during driving.

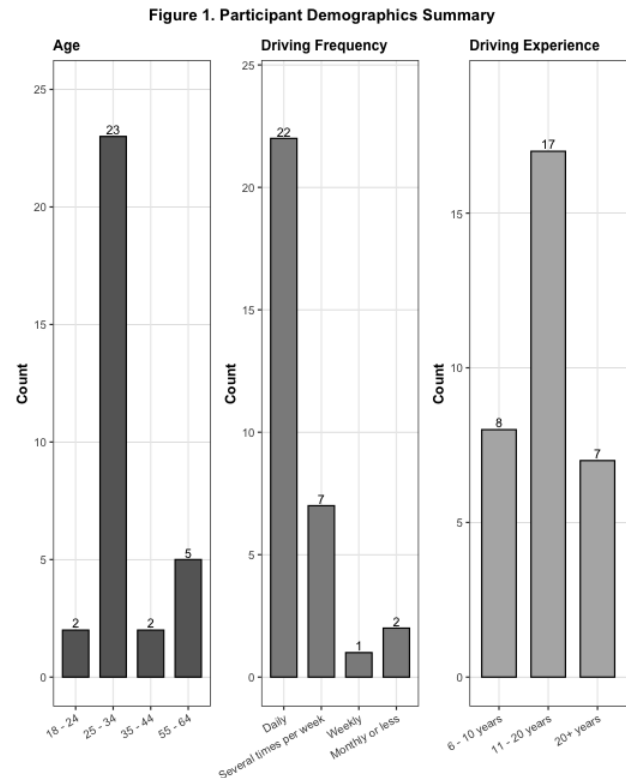
All attitudinal items were measured using a 7-point Likert scale ranging from Strongly Disagree to Strongly Agree. Parallel wording was used across control modalities to enable direct comparison between physical and touchscreen controls and to reduce potential wording bias.

To complement the quantitative ratings, participants were asked three open-ended questions. These items were included to capture contextual and experiential factors that may not be reflected in structured scale responses.

4 Evaluation

4.1 Respondents

A total of 32 participants (N=32) completed the survey. All participants were at least 18 years of age and reported prior experience interacting with automotive interfaces. Participants represented a range of driving frequencies and years of driving experience, with most reporting daily or frequent driving and multiple years of vehicle use (Figure 1). This variability provides a reasonable cross-section of users with differing levels of familiarity with both physical and touchscreen-based vehicle controls.



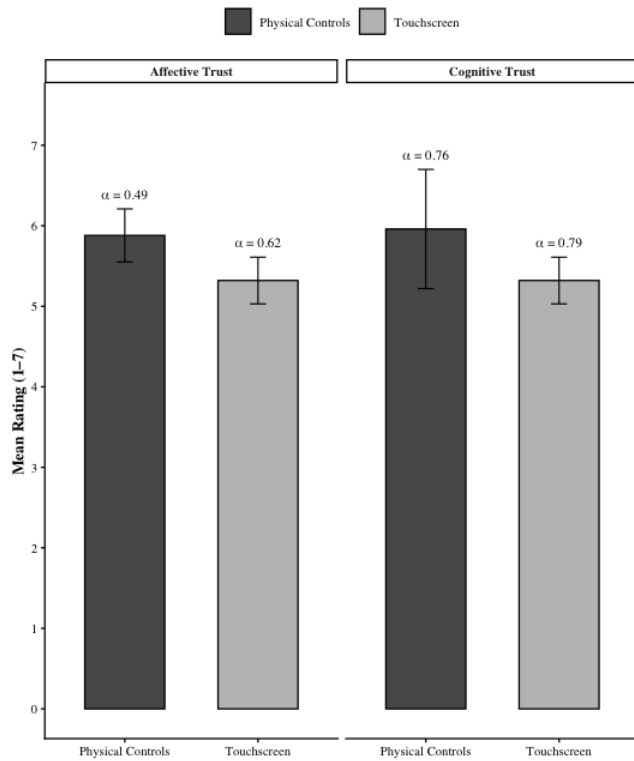
4.2 Data

A majority of the survey utilized a 7-point Likert scale (1 = Strongly Disagree, 7 = Strongly Agree). Based on the theoretical distinctions, trust was operationalized as two constructs: cognitive trust (predictability, reliability, and consistency) and affective trust (confidence, comfort, and perceived control). Each construct was further separated by control modality (physical vs. touchscreen).

Descriptive statistics revealed differences across modalities (Figure 2). Cognitive trust in physical controls was high ($M = 5.96$, $SD = 0.74$), while cognitive trust in touchscreen interfaces was lower ($M = 5.32$, $SD = 0.29$). Affective trust followed a similar pattern, with physical controls rated highly ($M = 5.88$, $SD = 0.33$) and touchscreen interfaces receiving slightly lower ratings ($M = 5.32$, $SD = 0.29$).

Response distributions, shown in Figure 3, revealed clustering toward the upper end of the scale, indicating a ceiling effect. This suggests that participants generally rated both modalities positively,

Figure 2. Mean Trust Ratings by Interface Type



while still demonstrating a consistent preference for physical controls.

4.3 Quantitative Analysis

Paired-samples t-tests were conducted for both cognitive and affective trust to evaluate the impact of control modality on user perceptions.

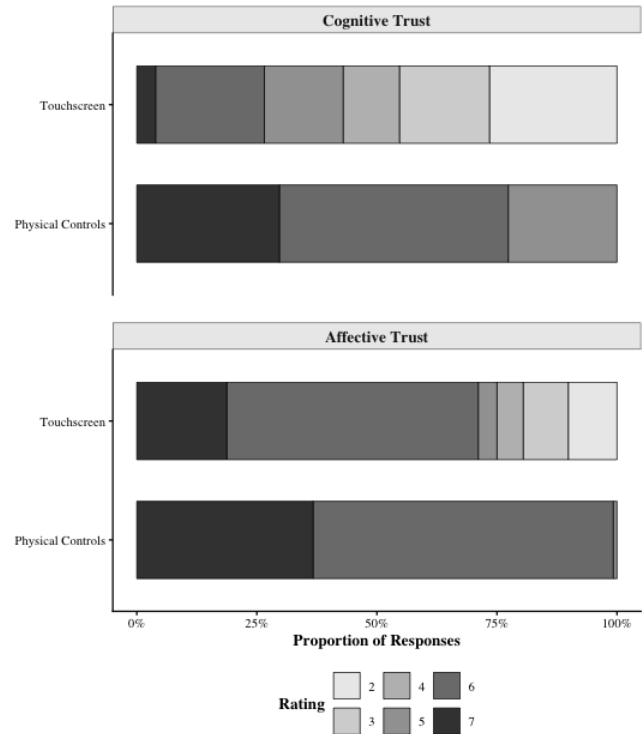
Cognitive trust was significantly higher for physical controls than touchscreen interfaces, $t(31) = 6.42$, $p < .001$, $d = 1.13$, indicating a large effect. Affective trust was significantly higher for physical controls, $t(31) = 7.11$, $p < .001$, $d = 1.26$, also reflecting a large effect.

Internal consistency was assessed using Cronbach's alpha. Cognitive trust demonstrated acceptable reliability (physical: $\alpha = .76$; touchscreen: $\alpha = .79$). Affective trust initially showed low reliability, but item-level diagnostics revealed that one item (Q21) exhibited minimal variance and weak item-total correlation. After removing this item, reliability for affective touchscreen trust improved to an acceptable level ($\alpha = .62$), while affective physical trust remained lower ($\alpha = .49$). Reliability for affective physical trust was below accepted thresholds ($\alpha = .49$), suggesting the construct may not have been fully captured by the selected items.

The results demonstrate that control modality has a statistically significant effect on both dimensions of trust, though differences should be interpreted in the context of generally high ratings across all conditions.

Figure 3. Response Distributions by Trust Construct

Ratings cluster toward the upper end of the scale, indicating a ceiling effect



4.4 Qualitative Analysis

In addition to Likert-Style questions, participants had the opportunity to respond to three optional open-ended questions describing their experiences with in-vehicle control systems. A few themes emerged as a result.

A majority of respondents described touch-based interfaces as requiring excessive visual attention. Participants frequently noted the need to “take [their] eyes off the road” and “read menus” to complete simple actions such as adjusting temperature or navigation. These responses suggest that touchscreens impose higher cognitive and visual load compared to physical controls. This reinforces the quantitative findings related to reduced perceived safety and lower affective trust.

Participants also emphasized issues with lack of tactile feedback, lag and inconsistent system behavior. Several respondents described touchscreens as “glitchy,” “laggy,” or requiring repeated inputs due to uncertain system registration. Others noted “you don’t know if the press worked,” highlighting ambiguity in interaction feedback. This theme aligns with lower cognitive trust scores, as users expressed diminished confidence in system reliability and predictability.

Physical controls were consistently associated with ease of use, muscle memory, and eyes-free interaction. Participants mentioned benefits such as steering wheel buttons and tactile knobs, which allow adjustments without visual confirmation. These features were perceived as more intuitive and safer, especially for frequent or time-sensitive actions.

Some participants did acknowledge the advantages of touchscreen systems such as navigation, customization, and software updates.

The qualitative responses gathered are valuable in that they reinforce quantitative findings by illustrating why touchscreen interfaces may reduce trust and usability in driving contexts. The data suggests a mismatch between interface design and user expectations in scenarios requiring low attention and high reliability. This expectation gap appears to contribute directly to both reduced cognitive trust and affective trust.

4.5 Limitations

Several limitations should be considered when interpreting these findings. Sample size ($N = 32$) is relatively small and may limit generalizability across broader populations. Responses were drawn using convenience sampling, which limits representativeness and introduces potential self-selection bias. The study relies on self-reported measures of past driving experiences, which may not fully reflect real-world driving behavior or performance. This also means that responses may be influenced by specific vehicle systems. Future research should incorporate controlled experiments, objective performance measures, and larger, more diverse samples to strengthen validity.

5 Discussion

The results of this study provide evidence that control modality influences both cognitive and affective dimensions of trust in automotive interfaces. Physical controls were consistently rated higher than touchscreen controls across both constructs. Participants generally reported high levels of trust across both modalities, suggesting that touchscreen systems are not inherently distrusted, but may be perceived as slightly less predictable and reliable.

The distinction between cognitive and affective trust reveals a more nuanced understanding of user experience. While touchscreen interfaces received lower ratings overall, affective trust scores were relatively high, indicating that users may feel comfortable using touchscreen systems even when they perceive them as less predictable.

The observed ceiling effect suggests that participants had difficulty differentiating between conditions at the upper end of the scale. This limited variance may have reduced sensitivity of the measures to detect more subtle differences in trust perceptions. Future studies may benefit from more discriminating scales or scenario-based measures.

6 Conclusion

This study examined how control modality influences trust in automotive interfaces. Physical controls were rated higher than touchscreen systems for both cognitive trust and affective trust. Participants viewed physical controls as more reliable, predictable, safe, and comfortable during driving. Touchscreen systems were generally rated positively, but lower overall. Qualitative responses suggest that visual demand, lack of tactile feedback, and interaction uncertainty reduce trust in touchscreen controls. These findings indicate that trust in vehicle interfaces depends not only on functionality, but also on how easily controls support low-effort and

eyes-free interaction. Future automotive systems should prioritize tactile feedback, predictability, and reduced driver distraction.

References

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Appendix

A Survey Instrument**Survey Title:** Automotive Control Types

Instructions: You are invited to participate in a research study focused on physical and touchscreen controls in cars. Your participation is voluntary. You may choose to stop at any time without penalty. Your responses will be anonymous.

You will be asked to evaluate two types of vehicle controls:

- Physical controls (buttons, knobs, switches)
- Touchscreen-based controls

SECTION 1: Consent and Demographics

Q1: By clicking, 'I consent' below, you acknowledge that you are 18 years or older and voluntarily agree to participate in this survey.

Q2: Age:

Q3: How often do you drive?

Q4: Years of driving experience:

Q5: My primary vehicle relies mostly on touchscreen controls.

Q6: I have experience using touchscreen-dominant vehicle interfaces.

Scale (7-point Likert): 1 = Strongly Disagree 4 = Neutral 7 = Strongly Agree

SECTION 2: Cognitive Trust: Physical Controls

Q7: Physical controls behave reliably during driving. Q8: Physical controls respond consistently when I use them. Q9: I can predict how physical controls will respond before I use them. Q10: Physical controls function as expected across situations.

SECTION 3: Cognitive Trust: Touchscreen Controls

Q11: Touchscreen controls behave reliably during driving. Q12: Touchscreen controls respond consistently when I use them. Q13: I can predict how touchscreen controls will respond before I use them. Q14: Touchscreen controls function as expected across situations. Q15: I have experienced unexpected behavior from touchscreen controls.

SECTION 4: Affective Trust: Physical Controls

Q16: I feel safe using physical controls while driving. Q17: I feel confident operating physical controls under time pressure. Q18: Using physical controls feels comfortable while driving. Q19: Physical controls make me feel in control of the vehicle system.

SECTION 5: Affective Trust: Touchscreen Controls

Q20: I feel safe using touchscreen controls while driving. Q21: I feel confident operating touchscreen controls under time pressure. Q22: Using touchscreen controls feels comfortable while driving. Q23: Touchscreen controls make me feel in control of the vehicle system.

SECTION 6: Comparative Evaluation

Q24: I feel more confident using physical controls than touchscreen controls. Q25: I feel more confident using touchscreen controls than physical controls.

SECTION 7: Open-Ended Questions

Q26: Describe a situation where you felt confident or uncertain using touchscreen controls while driving.

Q27: What features of physical controls influence your sense of reliability or safety?

Q28: What features of touchscreen systems influence your sense of reliability or safety?