Review article

Touchscreen Control Panels and Driver Distraction: What the Evidence Establishes, and the Familiarity Question It Leaves Open

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Highlights

- Thirty-two studies on in-vehicle touchscreen distraction were synthesised, including a fully screened Scopus search on familiarity.
- Naturalistic data place interaction with in-vehicle devices such as touchscreen menus at 4.6 times the crash odds of model driving.
- Drivers do learn: practice shortens task and glance times within a session, and steering steadies over repeated tasks.
- No study has tracked touchscreen visual demand beyond a single session; the one multi-day study found voice interactions stayed hard.
- An eight-week, preregistered study with between-session practice is proposed to test whether familiarity reduces visual demand.

Abstract

Background. Most new passenger cars put climate, media and navigation controls on a central touchscreen, and these screens are widely blamed for road crashes. The evidence behind that claim, and its limits, is rarely set out in one place.

Method. This narrative review combined an iterative literature search, a university library discovery search and a structured Scopus search on learning and familiarity, which was screened in full. Thirty-two studies were included and coded for setting, sample and theme. Six empirical studies read in full were appraised with the Mixed Methods Appraisal Tool.

Results. Touchscreen input consistently lengthens glances away from the road, slows tasks and raises workload compared with physical or voice controls. In naturalistic data, interacting with in-vehicle devices such as touchscreen menus carried 4.6 times the crash odds of model driving. On real roads, touchscreen input took about twice as long as speech input. Learning does occur: practice shortens task and glance times within a session, and lane keeping steadies over repeated tasks. Yet no study tracks touchscreen visual demand across days or weeks. The only multi-day study, of voice interfaces, found that interactions that were hard on the first day were still hard a week later.

Conclusions. Touchscreens are a demonstrated source of visual-manual distraction with crash-relevant consequences, but the evidence cannot yet say whether everyday familiarity removes the risk. An eight-week repeated-measures study is proposed to answer that question.

Keywords: driver distraction; in-vehicle information systems; touchscreen; visual demand; glance behaviour; practice effects; familiarity

1. Introduction

The centre stack of a modern car has become a screen. Climate, media, navigation, drive modes and, in some vehicles, wipers and mirror adjustment are now reached by touching glass. Hazoor and Marinelli (2026) describe the result well: these interfaces "centralize many previously manual or physical controls into a single digital surface" (Section 1). The shift happened quickly, with little public debate about safety.

The safety concern is mechanical. A physical knob can be found by feel, using tactile landmarks and motor memory, so the driver can keep looking ahead. A flat screen offers no landmarks, and every selection pulls the eyes away from the road. Strayer et al. (2019a) state the constraint plainly: "the visual system cannot process visual information from the forward roadway and information presented on a center stack display or heads-up display at the same time" (Introduction section). Drivers can switch between the two quickly, but they cannot look at both.

Distraction is common and costly. In a naturalistic study of more than 3,500 drivers, Dingus et al. (2016) found that some form of distraction was present during more than half of all driving and that distraction overall doubled crash risk. The odds rose to 4.6 times those of model driving when drivers interacted with an in-vehicle device other than the radio or the heating, ventilation and air conditioning (HVAC) controls, a category the authors illustrate with "touchscreen menus". In-depth investigation of fatal crashes in Norway attributed roughly 29% to driver inattention and about 8% to in-vehicle secondary tasks other than phone use (Sundfør et al., 2019, as cited in Hazoor & Marinelli, 2026).

Public discussion still runs ahead of the evidence. It is common to read that touchscreens are a leading cause of road crashes. Distracted driving as a whole is widely treated that way, but Hazoor and Marinelli (2026) add the qualification that matters: "official accident statistics rarely distinguish between touchscreen interfaces and traditional physical controls" (Section 1.1). The crash-risk category in Dingus et al. (2016) includes touchscreen menus but does not isolate them, and the data were collected before today's large displays became common.

A recent rapid review by DeGuzman et al. (2026) covered seventy-three studies of touchscreen safety and usability, searched four databases in February 2024 and concluded that "touchscreens tend to perform worse than physical/voice control with some exceptions" (Highlights). That review is broad, and the present one does not try to repeat it. DeGuzman et al. note that "the existing literature is not reflective of current touchscreen implementations" (Section 4), and their synthesis is organised around screen size, automation, task type, age and display design. It does not examine how drivers' visual demand changes as they become familiar with an interface. That question matters because almost every touchscreen study measures drivers within minutes of their first contact with the system, while real drivers use the same screen every day for years, or meet a new one each time they rent or share a car.

This review therefore has two aims. It synthesises what the evidence establishes about touchscreen distraction, and it examines, through a structured search, what is known about learning, practice and familiarity. The most important unanswered question is then turned into a study design. Section 2 describes the method, Section 3

reports the findings, Section 4 sets out the research gaps, Section 5 proposes a study, and Sections 6 and 7 give limitations and conclusions.

2. Method

2.1 Search strategy

Studies were identified through three searches. The first was an iterative search of Google Scholar and the publisher platforms ScienceDirect, SpringerLink, SAGE Journals, MDPI, Nature Portfolio and PNAS, combining interface terms (touchscreen, in-vehicle information system [IVIS], infotainment, centre stack, human–machine interface [HMI]) with outcome terms (driver distraction, visual demand, glance behaviour, workload, crash risk). The second was a discovery search of the Amity University eLibrary on 25 October 2026 using the terms "touchscreen driver distraction". The third was a structured search of Scopus on 28 October 2026. Search A combined interface, driving and distraction terms and returned 816 records; it was run to size the field. Search B added a block of learning terms (practice, familiarity, longitudinal, repeated exposure, repetition, habituation, multiple sessions, learning curve, learning effect, over time, training) and returned 100 records, all of which were screened. Both search strings are given in Appendix B.

2.2 Eligibility

Studies were eligible if they reported empirical, computational or review work on driver interaction with an in-vehicle touchscreen or information system and measured at least one distraction-related outcome: glance behaviour, driving performance, task performance, workload, perceived safety or crash risk. They had to be published in a peer-reviewed journal or peer-reviewed proceedings. Studies of detection algorithms without driver data, head-up displays only, phones only, and non-road vehicles were excluded, as were custom interfaces built for competition vehicles.

2.3 Screening and selection

The iterative search yielded twenty-nine documents, of which seven were excluded as non-journal literature (Appendix A), leaving twenty-two. The eLibrary search returned thirty-four records: one was already included, twenty-eight did not meet the criteria, and five were added. Search B returned one hundred records. Titles were screened, with abstracts checked where relevance was unclear; ninety-one were excluded, four were already included and five were added. The final corpus contains thirty-two studies (Figure 1), reported in a flow diagram adapted from the PRISMA 2020 statement (Page et al., 2021). Screening was carried out by a single reviewer, which is discussed in Section 6.

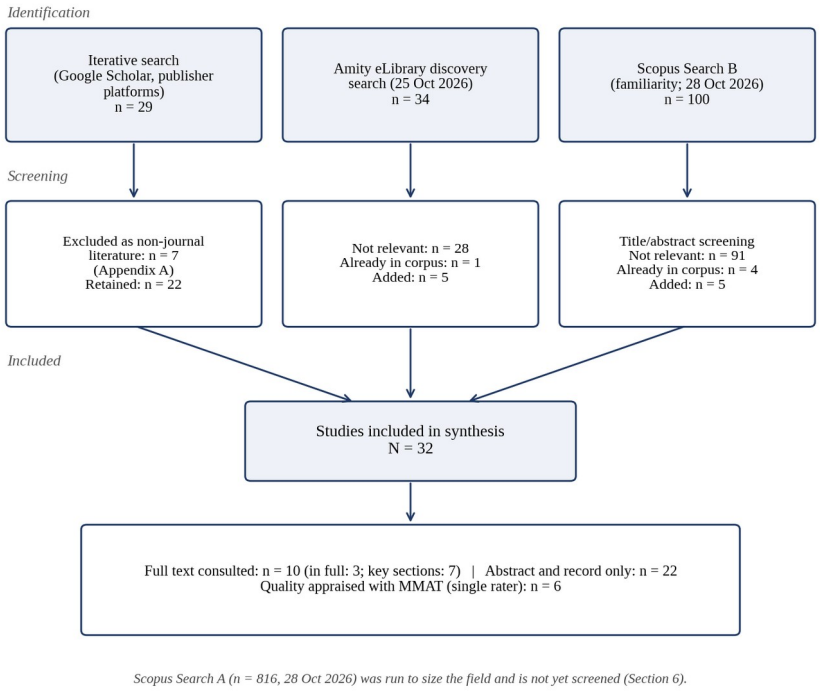


Figure 1. Identification, screening and inclusion of studies. Counts are from this review.

2.4 Verification

Every included study was resolved through its digital object identifier (DOI) in the Crossref registry, and the returned bibliographic details were checked against the citation. Host journals were confirmed in the Scopus source list.

2.5 Data extraction and full-text access

From each study the setting, sample size, interface, measures and quantitative results were extracted, along with the number of sessions and any practice or training manipulation. Full texts were consulted for ten studies: three were read in full and the key sections of seven were read. The remaining twenty-two are represented by their abstracts and bibliographic records, and claims about them are limited to what those records state. Where a record does not report a setting or sample size, Table 1 marks it as not stated (NS). Reported numbers were re-plotted as new figures for this review, with the source given in each caption. Quotations are taken from open-access articles licensed for reuse and are located by section where the article has no page numbers. Claims taken from one author's account of another study are cited as secondary sources.

2.6 Quality appraisal

Six empirical studies whose full texts were consulted, and which bear directly on the familiarity question or provide key effect sizes, were appraised with the Mixed Methods Appraisal Tool (MMAT), version 2018 (Hong et al., 2018). Following the tool's guidance, each criterion is rated yes, no or can't tell, and no overall score is calculated. Reviews, the computational tool and the framework paper fall outside the MMAT categories and were not appraised.

3. Results

3.1 Characteristics of the included studies

Table 1 lists the thirty-two studies. Simulator studies dominate, with sixteen of thirty-two, followed by six on-road studies and two that combine simulator and road testing (Figure 2). Two studies use naturalistic data: Dingus et al. (2016) and Ebel et al. (2023), whose model was trained on 12,142 touchscreen task engagements recorded in production vehicles. Reported samples are modest (Figure 3). Of the thirteen driving studies that state a sample, nine have forty participants or fewer; the largest are Strayer et al. (2016), with 257 drivers, and the two Hazoor studies, which report the same sixty drivers.

Table 1

Characteristics of the 32 included studies

Study	Venue	Setting	N	Focus
Ban & Park (2024)	Human Factors	Simulator (SAE Level 3)	NS	Screen location × task difficulty; take-over
Bucsuházy et al. (2026)	IATSS Research	On-road, eye-tracking glasses	NS	Necessary vs in-vehicle off-forward glances
Cescon & Peruzzini (2026)	Applied Sciences	Systematic review	82 papers	Evaluation methods for automotive HMIs
DeGuzman et al. (2026)	Transp. Res. Interdiscip. Perspect.	Rapid review	73 studies	Touchscreen safety and usability
Dingus et al. (2016)	PNAS	Naturalistic	> 3,500 drivers	Crash risk factors
Ebel et al. (2023)	Accid. Anal. Prev.	Naturalistic (production vehicles)	12,142 engagements	Explainable prediction of visual demand
Eren et al. (2018)	IET Intell. Transp. Syst.	Simulator	25	Muscle memory vs peripheral vision; 24 trials
Feng et al. (2017)	Comput. Ind. Eng.	Computational (simulator-validated)	n/a	Cognitive-model usability toolkit
Fuller et al. (2008)	Proc. HFES Annu. Meet.	Simulator	16	Touchscreen position
Hazoor & Marinelli (2026)	Traffic Saf. Res.	Simulator, eye tracking	60	Short training: visual attention
Hazoor et al. (2026)	Transp. Res. Interdiscip. Perspect.	Simulator	60†	Short training; repeated task
Huo et al. (2024)	Int. J. Ind. Ergon.	Simulator	42	Tactile feedback and emotion
Jahn et al. (2009)	Human Factors	Driving study + standstill	NS	Skill acquisition, destination entry
Large et al. (2023)	IET Intell. Transp. Syst.	Simulator + on-road	19	Simulator validity for HMI testing
Li et al. (2025)	Accid. Anal. Prev.	Simulator + on-road	50	Car-following pressure, task, speed
Li et al. (2026)	Applied Sciences	Survey (structural model)	390	Affordance design, perceived safety
Liang et al. (2024)	Electronics	Simulator, eye tracking	35	Duration of display distraction
Liu et al. (2022)	Appl. Ergon.	Simulator	NS	Tap and slide zones on large screens
Masseno et al. (2023)	Springer (DIGICOM)	Laboratory simulation	20	Touchscreen vs physical buttons
Petzoldt et al. (2011)	Transp. Res. Part F	Simulator (LCT)	NS	Learning effects in the LCT
Petzoldt et al. (2014)	Appl. Ergon.	Simulator (LCT)	NS	Learning and transfer in the LCT
Pichen et al. (2023)	IEEE IV Symposium	Simulator	26	Habituated steering-wheel input vs touchscreen
Platten et al. (2013)	Transp. Res. Part F	Simulator	38	Continuous behavioural adaptation

Study	Venue	Setting	N	Focus
Pool & Vardar (2024)	IFAC-PapersOnLine	Research framework	n/a	Vibration-robust, haptic touchscreens
Soomro & Cockburn (2020)	IEEE CITISIA	Simulator	NS	Tactile stencil overlays
Strayer et al. (2016)	Cogn. Res. Princ. Implic.	On-road, 5-day practice	257	Voice-based IVIS workload over a week
Strayer et al. (2019a)	Cogn. Res. Princ. Implic.	On-road	NS	Visual and cognitive demand protocol
Strayer et al. (2019b)	Human Factors	On-road	24 per configuration	CarPlay, Android Auto vs native
Wei et al. (2026)	Proc. IMechE Part D	Simulator	NS	Task complexity and workload
Zhao et al. (2023)	Displays	On-road	NS	Distraction pattern classification
Zhong et al. (2024)	Scientific Reports	On-road, instrumented car	28	Input modality × task type
Zuo et al. (2026)	Displays	Simulator, eye tracking	NS	Graphical design of touch buttons

Note. NS = not stated in the abstract or sections consulted; n/a = not applicable; LCT = lane change task; SAE = SAE International levels of driving automation. †Same sample as Hazoor and Marinelli (2026).

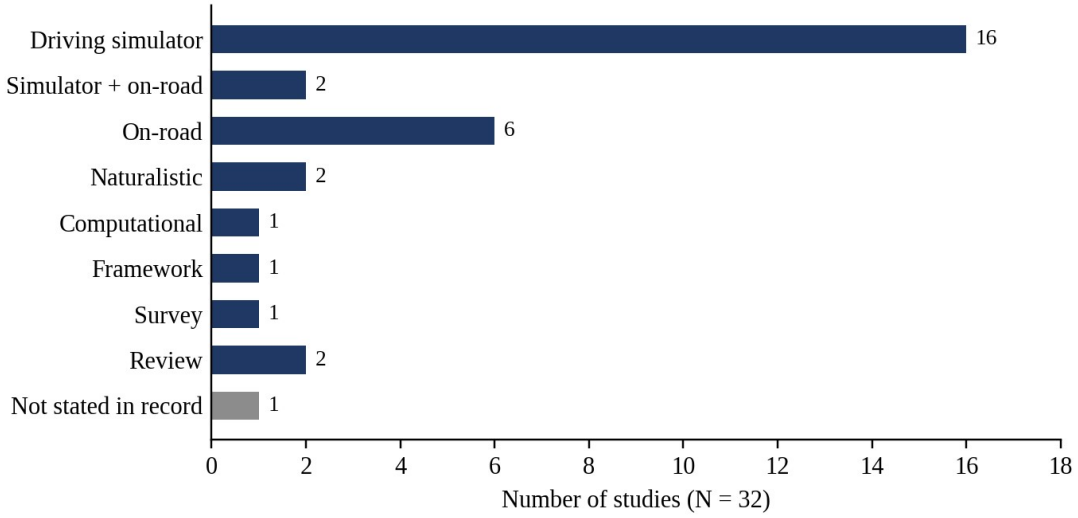


Figure 2. Study settings across the 32 included studies, as coded by this review.

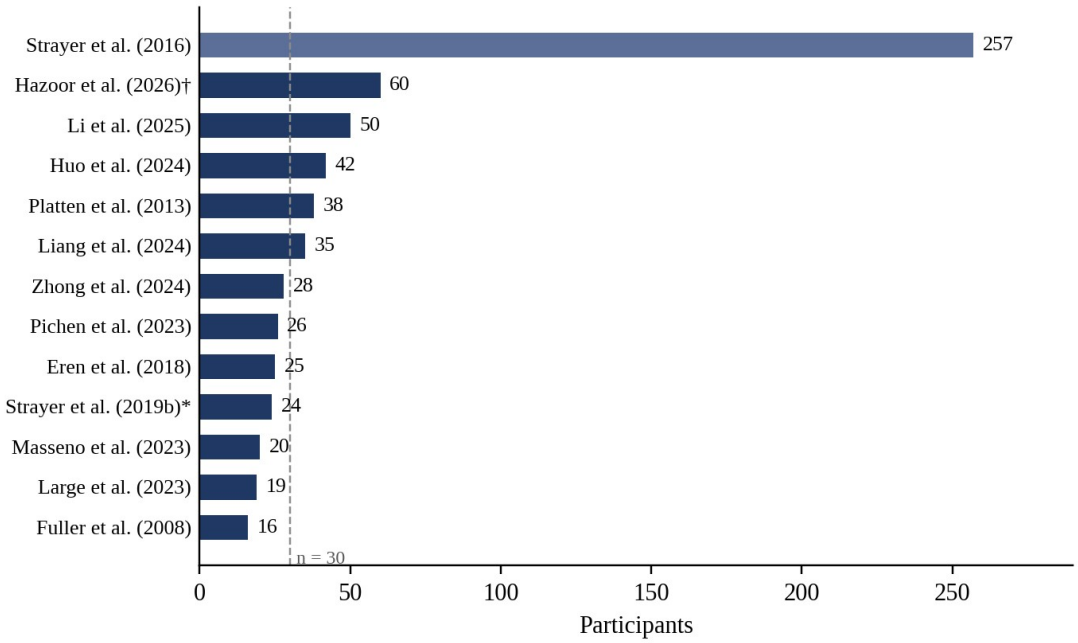


Figure 3. Sample sizes of primary driving studies that report participant numbers.

Note. *Per configuration (five vehicles × three systems). †The two Hazoor studies report one sample of 60 drivers. Dingus et al. (2016), Ebel et al. (2023) and the survey by Li et al. (2026) are omitted because their units differ.

3.2 Evidence map

Table 2 codes each study against nine themes. Interface design, measurement and validation, and learning or adaptation draw the most attention, with eleven studies each. Crash or outcome risk is covered by a single study, and countermeasures by five, most of them small or preliminary.

Table 2

Evidence map: themes addressed by each study

Study	A	B	C	D	E	F	G	H	I
Ban & Park (2024)			•		•				
Bucsuházy et al. (2026)		•					•		
Cescon & Peruzzini (2026)							•		
DeGuzman et al. (2026)		•	•	•	•				
Dingus et al. (2016)	•								
Ebel et al. (2023)			•		•		•		
Eren et al. (2018)			•					•	
Feng et al. (2017)							•		
Fuller et al. (2008)			•						
Hazoor & Marinelli (2026)								•	•
Hazoor et al. (2026)								•	•
Huo et al. (2024)		•							
Jahn et al. (2009)							•	•	
Large et al. (2023)							•		
Li et al. (2025)			•			•		•	

Study	A	B	C	D	E	F	G	H	I
Li et al. (2026)			•						
Liang et al. (2024)							•	•	
Liu et al. (2022)			•						
Masseno et al. (2023)		•							
Petzoldt et al. (2011)							•	•	
Petzoldt et al. (2014)							•	•	
Pichen et al. (2023)		•			•				•
Platten et al. (2013)						•		•	
Pool & Vardar (2024)		•							•
Soomro & Cockburn (2020)			•						•
Strayer et al. (2016)				•				•	
Strayer et al. (2019a)				•			•		
Strayer et al. (2019b)				•					
Wei et al. (2026)			•			•			
Zhao et al. (2023)							•		
Zhong et al. (2024)				•				•	
Zuo et al. (2026)			•						
Studies per theme	1	6	11	5	4	3	11	11	5

Note. A = crash or outcome risk; B = touchscreen vs other controls; C = interface design; D = input modality; E = automated driving; F = traffic context and demand; G = measurement, prediction and validation; H = learning, practice and adaptation; I = countermeasures. Coding by this review.

3.3 Visual-manual interaction and crash risk

Dingus et al. (2016) analysed crashes in a naturalistic database collected with in-car video and sensors. Activities that took the eyes off the road carried the highest risk (Figure 4). Interacting with an in-vehicle device other than the radio or HVAC controls, illustrated by touchscreen menus, raised the odds of a crash 4.6-fold, more than overall handheld phone use (3.6) or drowsiness (3.4). Tuning the radio was among the more benign activities. This is the strongest outcome evidence in the corpus, and it includes touchscreen interaction, but the category also contains other devices and the data predate today's large displays.

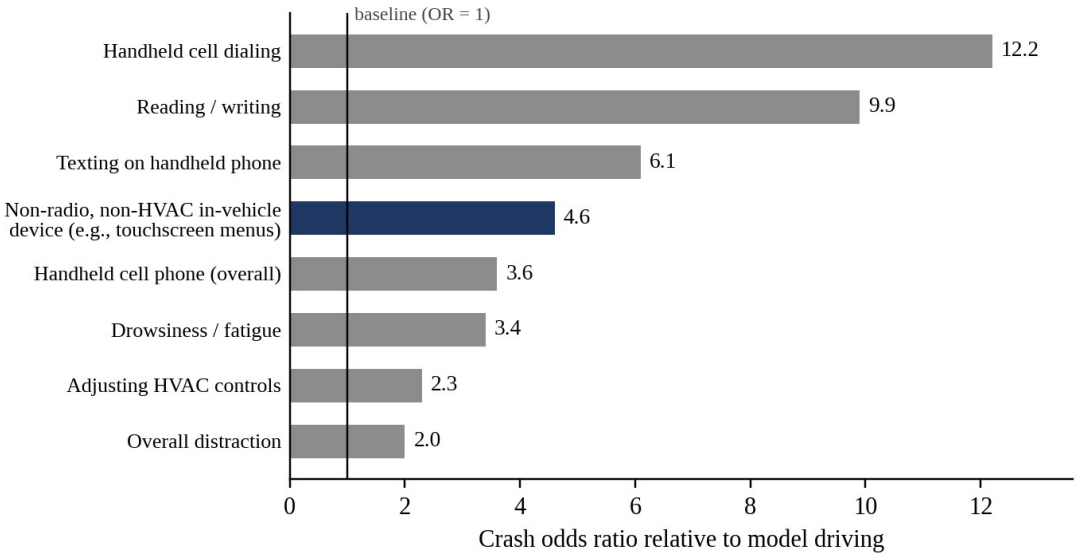


Figure 4. Crash odds ratios relative to model driving for selected risk factors in naturalistic data.
Note. Data from Dingus et al. (2016). Re-plotted for this review.

The other studies measure surrogates: how long and how often drivers look away, lane keeping, task time, responses to a detection-response task (DRT) and felt workload. Regulators rely on the same surrogates. The National Highway Traffic Safety Administration (NHTSA, 2013) guidelines ask that tasks be completable with single glances of two seconds or less and no more than twelve seconds of total eyes-off-road time. As Strayer et al. (2019a) explain, the 12-second rule "is based on the societally acceptable risk associated with tuning an analog in-car radio" (Introduction section), and they summarise an exposure argument from Shutko and Tijerina (2006) that "a task that takes twice as long to complete will result in twice the potential risk of an adverse event" (Introduction section). Bucsuházy et al. (2026) give these thresholds a useful reference point. In on-road driving, glances needed to check the situation behind the car never needed to exceed two seconds, whereas "touchscreen interactions pose the highest visual distraction risk with the highest share of glances exceeding 1.2 s, respectively 2 s" (Highlights).

3.4 Touchscreens compared with physical controls

Masseno et al. (2023) compared touchscreen and physical-button input with twenty participants in a laboratory simulation. Reaction times were significantly longer on the touchscreen, and 80% of participants made errors with it compared with 20% on physical buttons. Huo et al. (2024) studied emotion in forty-two drivers using the Self-Assessment Manikin (SAM), a 9-point rating scale. They report that the touchscreen interface "evokes higher valence ratings (+0.75) and lower dominance ratings (−0.52) than physical buttons" (Discussion section). Drivers felt more pleasant but less in control.

DeGuzman et al. (2026) found that most of the seventy-three studies they reviewed, including recent ones, reported worse driving performance, visual attention and task performance with touchscreens than with physical controls. In one on-road study they cite, 41% of glances to climate controls exceeded two seconds on a touchscreen against 27% with physical controls (Zhao et al., 2022, as cited in DeGuzman et al., 2026). Simulator work summarised by Zhong et al. (2024) ranks touchscreen input as the most demanding, followed

by gesture and then speech (Zhang et al., 2023, as cited in Zhong et al., 2024). Pichen et al. (2023) went further and replaced the touchscreen with an input drivers already know from manual driving. In a simulator study with twenty-six drivers, responding through the steering wheel produced significantly fewer dangerous overtakes that led to collisions than the touchscreen, and higher usability ratings.

3.5 Interface design factors

Screen position matters. Fuller et al. (2008) placed a touchscreen in four positions in a simulator and found mean task time rose from 17.8 seconds at the nearest position to 35.1 seconds at the farthest. On large screens, Liu et al. (2022) found that tap accuracy fell at positions blocked by the driver's arm or far from the driver, and mapped zones that most users could reach easily. Layout matters more than size: larger screens shortened glances only slightly, while interface design had a much bigger effect (Grahn & Kujala, 2020, as cited in Hazoor & Marinelli, 2026). Zuo et al. (2026) compared fifteen touch-button designs in simulated driving with eye tracking and found that dynamic colour change, colour projection, circular shape, negative polarity and visible boundaries gave the best visual usability. In a survey of 390 drivers, Li et al. (2026) found that interactive affordance, meaning how clearly a control signals and confirms its use, was the strongest predictor of perceived safety, although the authors caution that their affordance dimensions overlap heavily.

Task demands and traffic interact with design. Wei et al. (2026) found that touchscreen task complexity significantly affected driving behaviour and workload during simulated car-following, and their Bayesian model classified workload correctly for 87.0% of test samples and 84.30% under cross-validation. Li et al. (2025) tested fifty drivers on road and in a simulator. Mean off-road glance duration was 21.3% shorter when following another vehicle, and at higher speeds drivers made shorter but more frequent glances. Drivers adjust their glance strategy to the traffic around them, a pattern that matters for how laboratory results transfer to the road. Platten et al. (2013) reached a similar conclusion with thirty-eight drivers in a simulator: analysed continuously, drivers adapted their driving and cut back their infotainment activity as critical situations approached, managing their own workload rather than simply absorbing it.

3.6 Input modality

The clearest on-road comparison is Zhong et al. (2024), who tested twenty-eight young drivers in an instrumented production car (Figure 5). Compared with speech input, visual-manual input increased task completion time by about 104%, the number of glances by about 50% and total glance duration by about 52%. In the authors' words, the road setting "further exacerbates the significant differences between the two input modalities" (Discussion section). Drivers slowed down to compensate (Figure 6), but "self-regulating behaviors adopted by young drivers did not fully offset the adverse impact of IVIS-related distractions" (Discussion section).

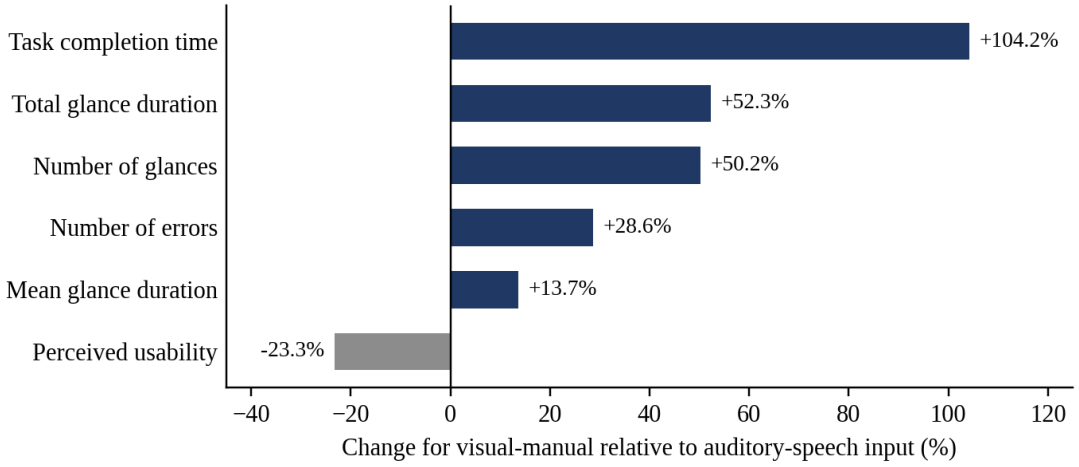


Figure 5. Effect of visual-manual relative to auditory-speech input during on-road driving (N = 28).
Note. Data from Zhong et al. (2024). Re-plotted for this review.

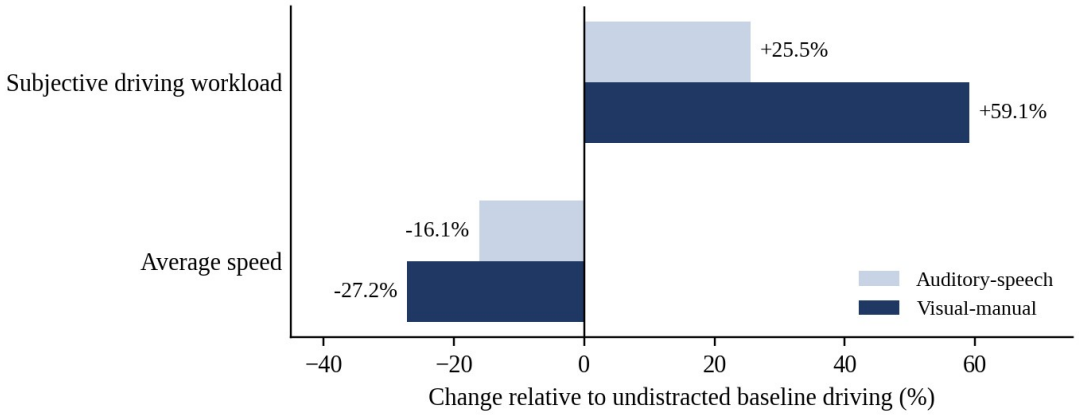


Figure 6. Change in average speed and subjective driving workload relative to undistracted driving, by input modality.
Note. Data from Zhong et al. (2024). Re-plotted for this review.

Implementation matters as much as modality. Across five vehicles, with twenty-four participants per configuration, manufacturers' embedded systems produced more workload than Apple CarPlay or Android Auto (Strayer et al., 2019b). Two interfaces on the same hardware can differ by more than some touchscreens differ from physical controls, so "touchscreen" is not a single exposure.

3.7 Automated driving

Ban and Park (2024) found that touchscreen location under conditional automation (SAE International Level 3) traded side-task performance against take-over performance: the lower-right position helped the first and hurt the second. In naturalistic data from production vehicles, Ebel et al. (2023) identified driving automation, together with interface element type and vehicle speed, as factors shaping visual demand; DeGuzman et al. (2026) report that touchscreen interactions increased while drivers used adaptive cruise control and lane centring.

3.8 Measurement, prediction and validation

Strayer et al. (2019a) built a standardised protocol combining a DRT, glance measures and subjective workload. They also found that for visually demanding touchscreen selections, "the time to perform an IVIS interaction in a moving vehicle was an increasing linear function of the time to perform the same interaction in a stationary vehicle" (Experimental overview section), so stationary testing understates demand. Feng et al. (2017) built a software toolkit on a cognitive model of the driver; validated in a fixed-base simulator with touchscreen, button and knob radio tuning, it estimated task time, total eyes-off-road time and workload close to the empirical values. Ebel et al. (2023) predicted which interactions would contain long glances with 68% accuracy and total glance duration with a mean error of 2.4 seconds. Liang et al. (2024) found the effect of distraction duration was non-linear: "This adaptation points to a threshold beyond which the negative effects of distractions no longer intensify" (Abstract). Large et al. (2023) showed that drivers made "more and longer off-road glances when interacting with the interface" on road than in a simulator, but that the ordering of design effects was the same, which they call "good relative validity" (p. 1104). Zhao et al. (2023) classified drivers in on-road full-touch testing into aggressive, moderate and conservative distraction patterns; the aggressive group looked away less often but for longer.

3.9 Learning, practice and familiarity

Search B identified eight studies that examine how drivers' performance with in-vehicle interfaces changes with practice or familiarity (Table 3). Together they show that learning is real but that it has only been measured over short spans.

Table 3

Studies examining learning, practice or familiarity with in-vehicle interfaces

Study	Interface and task	Exposure examined	Outcome	Finding
Jahn et al. (2009)	Manual destination entry, two route-guidance systems	Repeated training trials, driving and standstill	Display glance time; task time	Glance and task times fell with practice; the less demanding interface was learned faster
Petzoldt et al. (2011)	Lane change task with secondary tasks	Repeated test encounters	Lane change performance	Improved after one encounter and stayed improved
Petzoldt et al. (2014)	Lane change task with realistic secondary task	Prior experience; transfer between tasks	Lane change and task performance	Learning confirmed; partial transfer between similar tasks
Strayer et al. (2016)	Voice-based IVIS in ten vehicles	5 days of home practice (N = 257)	Cognitive workload	Practice did not eliminate interference
Eren et al. (2018)	Touchscreen button press	24 trials, one session (N = 25)	Task time	Fell only when drivers relied on muscle memory
Hazoor & Marinelli (2026)	Touchscreen; short demonstration	Trained vs untrained, one session (N = 60)	Fixations; gaze transitions	Small, non-significant improvement
Hazoor et al. (2026)	Touchscreen; repeated radio task	3 repetitions, one drive (N = 60)	Lane-position variability	Improved from first to third repetition
Pichen et al. (2023)	Steering-wheel input vs touchscreen	Relies on habits from manual driving (N = 26)	Dangerous overtakes; usability	Habituated input safer

Note. All but Strayer et al. (2016) measured learning within a single session or test series.

Jahn et al. (2009) fitted the power law of practice, under which performance improves quickly at first and then more slowly, to drivers learning manual destination entry, and found display glance times fell with training at

rates that could be predicted from stationary testing. The lane change task, an ISO-standardised simulator test, shows the same learning: performance improved significantly after a single encounter and stayed improved, and learning transferred partly between similar tasks (Petzoldt et al., 2011, 2014). On touchscreens specifically, Eren et al. (2018) found button-press times fell over twenty-four trials only when drivers relied on muscle memory with their peripheral vision blocked; when they could use peripheral vision, times were constant from the start.

Within a single drive, Hazoor et al. (2026) asked sixty drivers to perform the same radio task three times and found that lane-position variability decreased significantly from the first to the third repetition. The authors interpret this as evidence that "repeated engagement in the same secondary task enhances lateral control, reflecting a self-learning process in which drivers adapt their steering behaviour over time" (Discussion section). A short pre-drive training session, by contrast, increased task completion rates but did not improve driving performance (Hazoor et al., 2026), and its effect on eye movements was small and not statistically significant (Hazoor & Marinelli, 2026). Trained drivers nonetheless rated the training highly (Figure 7) and reported higher temporal demand and effort, which the authors attribute to greater awareness of the task. The training was "an observational demonstration rather than interactive hands-on practice" (Hazoor & Marinelli, 2026, Section 4.1).

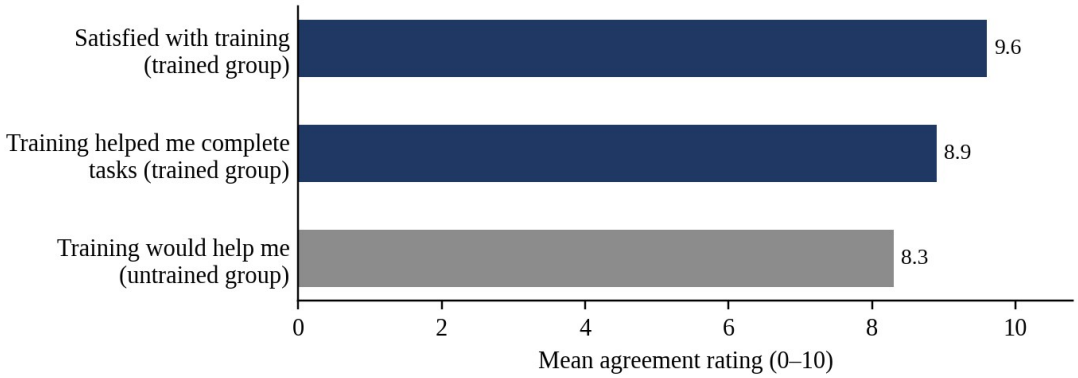


Figure 7. Self-rated value of a short pre-drive touchscreen training session.

Note. Data from Hazoor and Marinelli (2026, Section 4). Between-group differences in eye-tracking measures were not statistically significant. Re-plotted for this review.

The only study that followed drivers across days is Strayer et al. (2016). In ten model-year 2015 vehicles, 257 drivers aged 21 to 70 were tested, took the car home for five days of practice and were tested again. Workload averaged 3.34 on a five-point scale and was higher for older drivers. "IVIS interactions that were difficult on the first day were still relatively difficult to perform after a week of practice" (Abstract). That study concerned voice-based interaction and cognitive workload. No study in the search measured touchscreen glance behaviour across more than one session.

3.10 Countermeasures

Evidence on remedies is thin. Soomro and Cockburn (2020) fitted tactile stencils that could work across interface layouts to a touchscreen; contrary to their aim, the stencils increased attentional demand and impaired

driving compared with the plain screen. Pool and Vardar (2024) outline a research programme on touchscreens that predict and correct finger movements disturbed by vehicle vibration and provide artificial tactile feedback, noting that touchscreens "cannot be operated by touch alone and always require users' visual focus" (Abstract). Habituated alternatives such as steering-wheel input (Pichen et al., 2023) and short training (Hazoor & Marinelli, 2026; Hazoor et al., 2026) complete a small and mostly preliminary set.

3.11 Quality appraisal

Table 4 reports the MMAT appraisal of six studies. All met the screening questions and used appropriate measures. The commonest weaknesses were convenience or age-restricted samples and incomplete reporting of attrition; confounding was generally handled through matched groups, counterbalancing or baseline comparisons.

Table 4

Methodological quality of six appraised studies (MMAT 2018, quantitative non-randomised criteria)

Study	3.1 Sample	3.2 Measures	3.3 Complete data	3.4 Confounders	3.5 As intended	Screening	N
Dingus et al. (2016)	CT	Y	CT	Y	Y	Y	3,500 +
Strayer et al. (2016)	Y	Y	CT	Y	CT	Y	257
Zhong et al. (2024)	CT	Y	CT	CT	Y	Y	28
Huo et al. (2024)	CT	Y	Y	Y	Y	Y	42
Hazoor & Marinelli (2026)	N	Y	CT	Y	Y	Y	60
Hazoor et al. (2026)	N	Y	CT	Y	Y	Y	60

Note. Y = yes; N = no; CT = can't tell. Criteria: 3.1 participants representative of the target population; 3.2 appropriate measurement of outcome and exposure; 3.3 complete outcome data; 3.4 confounders accounted for; 3.5 exposure delivered as intended. Ratings by a single reviewer from the sections consulted; they should be confirmed by an independent second rater. Dingus et al. purposely over-sampled younger and older drivers; the Hazoor studies recruited volunteers aged 23–55 through social media.

3.12 Summary of quantitative findings

Table 5 collects the quantitative results extracted from the corpus. Values are as reported by the source and were not recalculated.

Table 5

Quantitative findings extracted from the corpus

Source	Measure	Value	Context
Dingus et al. (2016)	Crash odds: non-radio, non-HVAC device (e.g., touchscreen menus)	4.6	Naturalistic
Dingus et al. (2016)	Crash odds: handheld phone overall / drowsiness / HVAC adjustment	3.6 / 3.4 / 2.3	Naturalistic
Dingus et al. (2016)	Crash odds: any distraction; share of driving time distracted	2.0; > 50%	Naturalistic
Sundfør et al. (2019)‡	Fatal crashes with inattention / other in-vehicle tasks	~29% / ~8%	Norway, in-depth
Zhong et al. (2024)	Task time, visual-manual vs speech	+104.2%	On-road, N = 28
Zhong et al. (2024)	Number of glances / total glance duration	+50.2% / +52.3%	On-road, N = 28
Masseno et al. (2023)	Participants making errors: touchscreen vs buttons	80% vs 20%	Lab, N = 20
Fuller et al. (2008)	Task time, nearest vs farthest screen position	17.8 s vs 35.1 s	Simulator, N = 16
Li et al. (2025)	Mean off-road glance duration when following a vehicle	−21.3%	Road + simulator, N = 50
Ebel et al. (2023)	Long-glance prediction accuracy / glance-duration error	68% / 2.4 s	Naturalistic
Wei et al. (2026)	Workload classification accuracy (test / cross-validation)	87.0% / 84.30%	Simulator
Huo et al. (2024)	Touchscreen vs buttons: valence / dominance (9-point)	+0.75 / −0.52	Simulator, N = 42
Li et al. (2026)	Interactive affordance → perceived safety (path coefficient)	β = 0.312	Survey, N = 390
Strayer et al. (2016)	Workload after first session (5-point scale)	3.34	On-road, N = 257

Source	Measure	Value	Context
Hazoor & Marinelli (2026)	Training satisfaction / helpfulness (0–10)	9.6 / 8.9	Simulator, N = 60
NHTSA (2013)	Single glance / total eyes-off-road limit	≤ 2 s / ≤ 12 s	Guideline

Note. ‡As cited in Hazoor and Marinelli (2026).

4. Research gaps

Table 6 summarises six gaps, the evidence for each and whether the study proposed in Section 5 addresses it.

Table 6

Research gaps, supporting evidence and tractability

Gap	Evidence in corpus	What would close it	Feasibility	Section 5
Touchscreen-specific outcomes	One naturalistic crash study; touchscreen menus included in a broader device category	Crash or near-crash risk for touchscreen use in current vehicles	Low	No
Ecological validity	16 of 32 studies simulator-only; on-road studies test one vehicle each	Multi-vehicle on-road comparisons	Medium	Partly
Familiarity over time	Learning shown within sessions; only multi-day study is voice-based	Repeated touchscreen measures over weeks	High	Yes
Unfamiliar vehicles and updates	Car sharing flagged; never measured	Rotating-interface and layout-change conditions	High	Yes
Confounded design variables	One or two factors per study	Factorial manipulation	High	No
Samples and countermeasures	Most samples ≤ 40; five small countermeasure studies	Larger age-balanced samples; tested remedies	Medium	Partly

Note. Feasibility reflects the resources needed by a single research group without fleet or insurer data.

4.1 Touchscreen-specific outcomes

Naturalistic data link interaction with in-vehicle devices, including touchscreen menus, to a 4.6-fold increase in crash odds (Dingus et al., 2016). The category also includes other devices, and the data were collected before today's large screens became standard. Ebel et al. (2023) show that touchscreen use can now be logged in production vehicles. Linking such logs to near-crash events would give the first touchscreen-specific outcome estimate for current vehicles.

4.2 Ecological validity

Half the corpus is simulator-only. Cescon and Peruzzini (2026), reviewing eighty-two evaluation studies, conclude that "current practices prioritise experimental control over ecological validity" and that "the absence of unified testing protocols continues to hinder comparability across studies and domains" (Section 5.1). Large et al. (2023) show simulators rank designs correctly but understate absolute glance behaviour, and Li et al. (2025) show drivers change their glance strategy with traffic, which a quiet simulated road may not provoke.

4.3 Familiarity over time

The corpus shows that drivers learn. Glance times fall with practice (Jahn et al., 2009), steering steadies across repetitions (Hazoor et al., 2026) and touch times fall when drivers can rely on muscle memory (Eren et al., 2018). But every touchscreen study stops at the end of one session. The one multi-day study, of voice interaction, found that difficult interactions stayed difficult after a week (Strayer et al., 2016). Whether touchscreen visual demand settles at a safe level after weeks of everyday use, or stays above the NHTSA

thresholds, is unknown. Single-session results therefore may overstate or understate the risk to people who own their cars.

4.4 Unfamiliar vehicles and software updates

Hazoor and Marinelli (2026) warn that the problem "may be further amplified in the context of the growth of car sharing services, where drivers frequently encounter unfamiliar vehicles" (Section 1). No study has compared drivers who meet a new interface each time with drivers who keep the same one, and none has measured the cost of relearning after an over-the-air (OTA) software update moves controls.

4.5 Confounded design variables

Touchscreen studies vary screen position, size, menu depth, gesture, graphics and feedback one or two at a time. DeGuzman et al. (2026) likewise note "a lack of systematic research on interactions between different factors" (Section 4). Factorial studies are needed before designers can tell which property to change first.

4.6 Samples and countermeasures

Nine of the thirteen driving studies that state a sample have forty participants or fewer, and age is rarely analysed although Strayer et al. (2016) found higher workload in older drivers. The five countermeasure studies are small, and one of them, tactile stencils, made performance worse (Soomro & Cockburn, 2020).

5. A proposed study: does touchscreen demand decay with familiarity?

The familiarity gap is consequential and can be studied with ordinary resources. It also decides how the rest of the evidence should be read. If touchscreen visual demand falls substantially with everyday use, single-session studies overstate the risk for owners. If it does not, the existing literature is conservative and the case for physical controls for frequent functions strengthens. Prior evidence points both ways: learning is fast within sessions (Hazoor et al., 2026; Jahn et al., 2009), but a week of practice did not make hard voice interactions easy (Strayer et al., 2016).

5.1 Aim and hypotheses

The study will measure how touchscreen visual demand changes with repeated use over eight weeks, estimate the extra demand of an unfamiliar interface, measure the cost of relearning after a layout change, and test whether drivers feel adapted before their eye movements show it. Table 7 sets out the hypotheses. The fourth follows from the finding that trained drivers rated their training highly while their gaze changed little (Hazoor & Marinelli, 2026).

Table 7

Hypotheses, predictions and tests

	Prediction	Primary measure	Test
H1	Visual demand falls from session 1 to session 2 and then levels off; task time and glance count improve more than mean single-glance duration	Total eyes-off-road time; mean glance duration	Session effect, consistent group; shape of curve
H2	Drivers who meet a new interface each session show no comparable fall	Total eyes-off-road time	Session × group interaction
H3	Moving two frequent controls before session 4 raises demand partway back towards session 1	Eyes-off-road time, session 3 vs 4	Planned contrast, consistent group

	Prediction	Primary measure	Test
H4	Subjective workload falls faster and further than eyes-off-road time	NASA Task Load Index (NASA-TLX) vs eyes-off-road time (standardised)	Divergence across sessions

5.2 Design and participants

The design is a 2 (interface condition, between subjects) × 4 (session, within subjects) mixed design across eight weeks (Figure 8). Sixty licensed drivers with at least two years' experience will be recruited, with quotas to balance age from 21 to 70; age will be entered as a continuous covariate rather than a grouping factor, to avoid small cells. Thirty drivers will keep the same interface throughout. Between sessions they will practise on a tablet replica of that interface for about ten minutes on at least four days a week, with use logged by the application, so that familiarity builds from everyday-like exposure rather than four laboratory visits alone. The other thirty will meet a different interface at each session, representing rental and car-sharing use. To keep novelty separate from difficulty, the four interfaces will be matched for baseline demand in a pilot study with about eight drivers, and their order will be counterbalanced with a Latin square. Prior touchscreen familiarity and car-sharing frequency will be recorded as covariates, as Hazoor and Marinelli (2026) recommend.

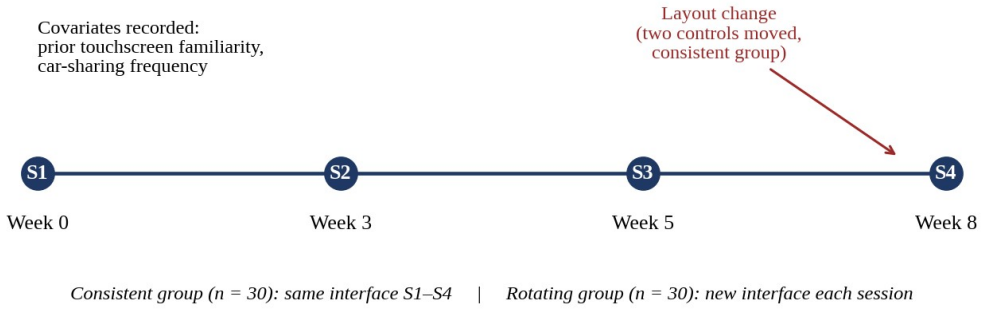


Figure 8. Design of the proposed study.

5.3 Apparatus, tasks and measures

Testing will use a fixed-base driving simulator with a representative centre-stack touchscreen and a remote eye tracker, with glance coding following ISO 15007 (International Organization for Standardization, 2020). The host facility and equipment will be confirmed before preregistration. Because simulators understate absolute glance behaviour while ranking conditions correctly (Large et al., 2023), the study's inferences rest on changes within and between groups rather than absolute values. The driving task is car-following on a two-lane road at varying headway. Secondary tasks are climate adjustment, media selection and destination entry, chosen to span shallow and deep menus and to remain comparable with Strayer et al. (2019a) and Zhong et al. (2024). All tasks are performed while driving, because stationary testing understates touchscreen demand (Strayer et al., 2019a). Before session 4, two frequently used controls in the consistent group's interface will be moved to simulate an OTA update. Table 8 lists the measures.

Table 8

Dependent measures and covariates

Construct	Measure	Unit	Basis
Visual demand	Total eyes-off-road time per task	s	NHTSA (2013); ISO 15007
Visual demand	Mean single-glance duration	s	ISO 15007
Visual demand	Glances longer than 2 s	% of glances	NHTSA (2013); Bucsuházy et al. (2026)
Lateral control	Standard deviation of lane position (SDLP)	m	Hazoor et al. (2026)
Longitudinal control	Headway variability	s	Li et al. (2025)
Task performance	Task completion time; error count	s; count	Zhong et al. (2024)
Workload	NASA Task Load Index (NASA-TLX)	0–100	Strayer et al. (2019a); Zhong et al. (2024)
Exposure	Logged practice minutes between sessions	min	This study
Covariates	Age; prior touchscreen familiarity; car-sharing frequency	years; self-report	Hazoor & Marinelli (2026)

5.4 Analysis and statistical power

Linear mixed-effects models with session and interface condition as fixed effects, participant as a random intercept, and logged practice and age as covariates will test H1 and H2. The shape of the session effect will be estimated rather than assumed, in light of the non-linear patterns reported by Liang et al. (2024) and the power law of practice (Jahn et al., 2009). H3 will be tested with a planned contrast between sessions 3 and 4 in the consistent group, and H4 by modelling the gap between standardised workload and standardised eyes-off-road time across sessions. For a repeated-measures analysis of variance with two groups, four sessions, $\alpha = .05$ and an assumed correlation of .50 between sessions, sixty participants give 80% power to detect a session × group interaction of $f = 0.15$, a small-to-medium effect; mixed models are expected to be at least as efficient.

5.5 Ethics, preregistration and contribution

Approval will be sought from the Amity University institutional ethics committee before recruitment. Participants will give informed consent and will be screened for simulator sickness. The hypotheses, analysis plan and exclusion rules will be preregistered on the Open Science Framework before data collection. The design gives an interpretable answer either way. Strong adaptation would mean risk estimates from single-session studies need revising down. Weak adaptation would show that touchscreen visual demand is a property of the interface rather than a passing cost of unfamiliarity, and would strengthen the case for physical controls for frequent functions. Figure 9 sketches the pattern expected from the prior evidence: drivers getting faster without getting much safer, with subjective workload falling ahead of measured eyes-off-road time.

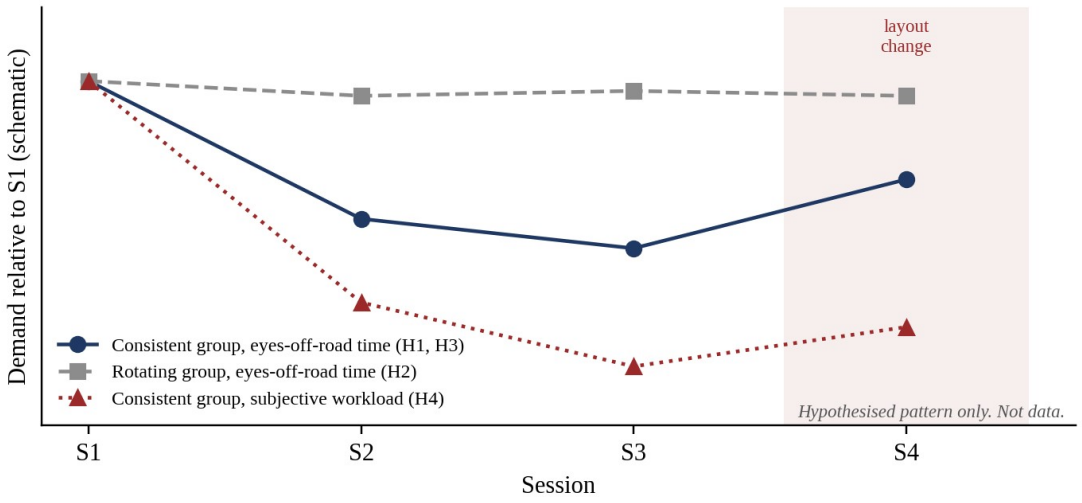


Figure 9. Hypothesised pattern of results for H1–H4.

Note. Schematic illustration of the hypotheses only. It contains no data.

6. Limitations

This is a narrative review with a structured component, not a full systematic review. The general corpus was assembled by iterative and library searching, and Scopus Search A (816 records) was run but not screened, so studies outside the familiarity question may be missing; the corpus is smaller than the seventy-three studies in DeGuzman et al. (2026). Search B was screened in full, mainly on titles, by one reviewer, and the quality appraisal was carried out by the same reviewer; both should be repeated by an independent second reviewer and agreement reported. Full texts were consulted for ten of thirty-two studies; the remaining claims rest on abstracts, which is why nine sample sizes are marked NS. Several figures come through other authors' summaries and are cited as secondary sources. The review is limited to English-language, peer-reviewed work, which leaves out grey literature, manufacturer data and unpublished null results, and probably tilts the evidence towards larger effects.

7. Conclusion

The evidence is consistent on one point. Touchscreen interaction takes the eyes off the road longer than physical controls, adds workload and degrades vehicle control, and naturalistic data tie interaction with in-vehicle devices, touchscreen menus among them, to a substantial rise in crash odds. Design choices such as position, layout and button graphics change the size of the penalty.

What the evidence cannot yet say is whether familiarity removes the penalty. Drivers clearly learn within a session, but no study has followed touchscreen visual demand across weeks of real use, and the only multi-day study, of voice interfaces, found hard interactions stayed hard. Until that question is answered, the most defensible statement is that touchscreen control panels are a demonstrated and substantial source of distraction with a measurable link to crash risk, while their share of real-world collisions remains unquantified.

Declarations

Author contribution. Parikshit Roy: conceptualisation, literature search, screening, data extraction, analysis, writing (original draft, review and editing).

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Competing interests. The author declares no competing interests.

Ethics. This review used published data only and did not require ethical approval. The proposed study in Section 5 will require approval before recruitment.

Data availability. No new data were collected. Extracted values are reported in Tables 1–5, and the search strings are given in Appendix B.

Declaration of generative AI use. During preparation of this work the author used Claude (Anthropic) to assist with database searching, retrieval and verification of bibliographic records, extraction of text from open-access articles, drafting and editing of prose, and production of figures from values reported in the cited studies. The extracted quotations and numerical values were checked against their source texts during preparation. The author reviewed and edited the manuscript and takes full responsibility for its content.

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Appendix A. Documents excluded as non-journal literature

Table A1

Documents retrieved by the iterative search but excluded

Document	Type	Identifier
How do drivers self-regulate their secondary task engagements? Driving automation, touchscreen interactions and glance behavior	Preprint	arXiv:2207.04284
Designing touchscreen menu interfaces for in-vehicle infotainment systems: Depth and breadth trade-off and task types	Preprint	arXiv:2404.11469
Impact of touchscreen menu complexity on driver performance and safety	Working paper	SSRN 5471227
Human-machine interface review: A comparison of legacy and touch-based center stack controls	Student thesis	VTechWorks, Virginia Tech
Visual and cognitive demands of using in-vehicle information systems	Technical report	AAA Foundation for Traffic Safety (2017)
Physical buttons outperform touchscreens in new cars, test finds	Magazine test	Vi Bilägare (2022)
Visual-manual NHTSA driver distraction guidelines for in-vehicle electronic devices	Regulatory guideline	Cited as a policy source, not a study

Appendix B. Scopus search strings (28 October 2026)

Search A (816 records). TITLE-ABS-KEY ((touchscreen* OR "touch screen*" OR "in-vehicle information system*" OR ivis OR infotainment OR "center stack" OR "centre stack" OR "in-vehicle display*") AND (driver* OR driving OR automotive OR "in-vehicle") AND (distract* OR "visual demand" OR glance* OR "eyes-off-road" OR workload OR "driving performance" OR "crash risk")) AND PUBYEAR > 1999 AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp")) AND (LIMIT-TO (LANGUAGE , "English"))

Search B (100 records). Search A with the following block added inside TITLE-ABS-KEY: AND (practice OR familiar* OR longitudinal OR "repeated exposure" OR repetition* OR habituat* OR "multiple sessions" OR "learning curve*" OR "learning effect*" OR "over time" OR training)