Automotive Interior: A study on the Dashboard Touch Screen Panel and Its Impact to the Driver

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Abstract. Touch screen panel on the automotive dashboard has changed rapidly following the new technology and latest features invented to provide a better driving experience. It also gives simpler and cleaner look inside the automotive interior as it removes some tactile control such as dial or knob for the entertainment function, air conditioning, button or switch for gears or parking brake. Like the fast-growing smartphone development, some of the touch screen panel especially on high end vehicle removes completely the tactile control for the entire function to control the car. For drivers who are familiar with a conventional tactile control, they will have an issue regarding the new experience especially when it comes to controlling entertainment system and air conditioning function. Past studies done by several people show it may distract the drivers' attention while driving as they need to focus on the driving itself instead of focusing on their touch screen panel.

Keywords: Touch screen panel, dashboard, distraction, driving experience.

1 Introduction

Driving a modern car is an entirely different experience for those of us who learnt to drive a few decades ago. Rear-view or 360-degree cameras, obstacle sensors, parking assist, lane-change assist, adaptive cruise controls, autopilot driving and browsing internet are now standard features or accessories in modern cars. Most of these features are intended to make driving experience feels safer and more pleasant. These features may achieve the said intention but under two conditions: first, automakers grasp the most basic aspect about human attention, which is finite; second, only if these advanced automotive features are designed in such a way that they do not divert cognitive resources away from the primary task of driving. Primary driving task aspects (controls, displays, and visibility), driver workspace (seating and packaging, vibration, comfort, and climate), driver condition (fatigue and impairment), crash injury, advanced driver-assistance systems, external communication access and driving behaviour are all classified as human factors.

There were only car stereos back in the day. User inserted physical media (Cassette or CD), turned a knob, or pushed a button to listen to the radio and there were some sliders to change the EQ settings. Small digital screens began to appear in car's centre consoles, offering built-in alternatives to the suction-cupped GPS units that had all but obliterated the road atlas. As those screens developed in capability, there was a greater desire to engage with them. Jogwheels, scroll- and touchpads and finally the touch screen have now replaced dedicated physical buttons.

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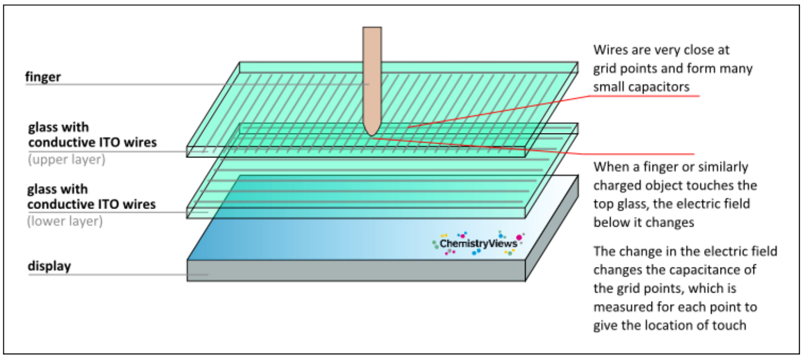

Fig 1. Multitouch Touch Screen Panel

Within their vehicles, drivers and passengers expect a growing variety of dynamic information, communication, and entertainment options. This is suitable for touch screen interfaces in terms of both form and function. Touch screens provide a big, flexible visual display, do not require peripheral devices like keyboards, and allow direct manipulation of information utilising interaction modes that drivers from non-automotive contexts may be accustomed with. Using touch screens while driving may consequently overburden or distract drivers, resulting in reduced driving performance and vehicle control, as well as an increased risk to drivers and other road users. It is unknown that being distracted by dashboard touch screen panel has ever been the blame of a road accident, it might as well fall under the category of human factor, yet there have been complaints on how it is a source of distraction to the drivers.

2 The Development of Touch Screen Technology

Touch screen technology has progressed at a breakneck pace in non-automotive applications, mostly in mobile phones and tablet computers. This has resulted in a set of features, ‘best-practice' interaction techniques, and ergonomic design recommendations that are well-suited to sedentary (non-automotive) environments. Multi-touch gestures, for example, can be used to offer visually captivating feedback by requiring two or more points of contact with the surface, such as pinch-to-zoom, and anchor-and-rotate. Touch screen interactions frequently rely on strong visual hints within the content displayed on screen or may use visual design metaphors to convey subtle communication. Virtual user interface (UI) elements, such as buttons that ‘depress' when pressed, pages of a book that ‘turn' when swiped or lists that ‘scroll' to allow users to move through them, are frequently presented on-screen to resemble their real-world counterparts.

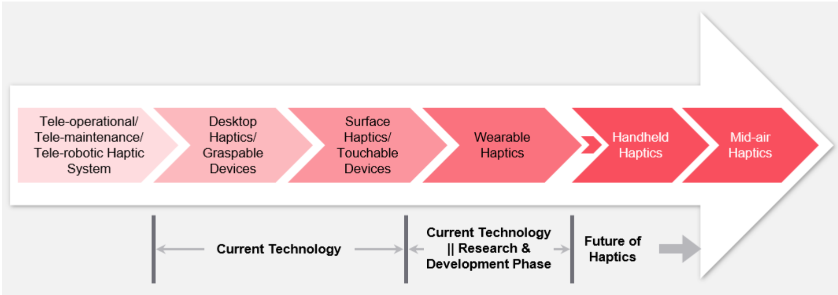

Fig 2. Advancement in haptic/touch devices. Source: FutureBridge Analysis

Furthermore, ergonomic, and anthropometric difficulties impact how people interact with smartphones and tablets and these are based on the expected configuration during use. Smartphones, for example, can be handled and operated with the same hand (dominant or favoured). As a result, smartphone interface elements are often found near the bottom of the screen (known as the 'thumb zone') so that the interface may be navigated with just a thumb. Similarly, the active zone of a tablet interface represents the device's most likely ergonomic setup. Tablets, unlike smartphones, can be handled and utilised in a variety of ways; for example, embraced like a book, held like a clipboard, propped up against a surface, or using a stand, hence the location of UI elements may vary depending on the application. Users will use their dominant hand to engage with a tablet, while their other hand will support the device.

Due to people's comfort to the use of touch screens in mobile phones and tablets, even notebooks and laptops, car makers around the world have initiated the idea of placing the same touch screen features into people's yet another commonly used item which is automobile.

3 Touch Screen Installation in Automobile

The fundamental controls for driving an automobile now are the same as they were a century ago. Accelerate by pressing one foot pedal, slow down by pressing another, and steer by turning a hand-operated wheel. Joysticks and other radical control solutions have been proposed over the years, but none have proven to be superior to wheels and pedals. However, car interiors have changed dramatically over the last decade or so in terms of drivers' other experiences with autos. The consumer electronics industry's high definition, multicoloured sparkle has spread throughout the business, with touch screens replacing dials and buttons.

Fig 3. Evolution of dashboard panel in Volkswagen Golf

Because of its design flexibility, speed, and convenience, touch technology has become an everyday aspect of our lives and is employed in a variety of scenarios. Touch screens give dynamic controls that can be adjusted depending on the features that are required to be added to the system, whereas traditional electronic devices are constrained to the initial design (i.e. fixed physical controls) and are not capable of updates (McGooking et al., 2008). The use of touch screens in automobiles has expanded dramatically during the previous decade.

Fig 4. Driver using Touch Screen Panel

Due to space constraints in car interiors, a touch screen is most likely to be installed in the centre console. As a result, right-hand drive car drivers in the United Kingdom are frequently forced to interact with the touch screen with their non-preferred or non-dominant hands. Drivers' attention should not be diverted from the primary objective of driving within a vehicle, though. Given the visual cues/feedback and physical dexterity necessary to handle these devices, particularly for drivers who use their non-dominant hand, it is likely that some of the present interface strategies may divert drivers' attention away from vital driving-related activities (Lee et al. 2008). This is expected to have negative consequences for steering (Liang & Lee 2010), lane position maintenance (Land & Horwood 1995), and hazard recognition (Liang & Lee 2010, Crundall et al., 2012), resulting in a higher crash risk (NHTSA 2006).

As much as it seems like a good idea to use touch screens in everyday lives, it is often the primary task in a sedentary situation. As a result, it can easily absorb the user's complete visual attention, which means it may not be a good idea to be used while the user is in motion. The literature has acknowledged that these displays may cause driving distraction. According to Knipling et al. (1993), the drivers turning their attention away from the road to interact with in-vehicle displays was responsible for 24 percent of rear-end collisions. For automobile makers, the presence of a touch screen and the functions it may give has become a highly advertised feature. As a result of this increase, it is now necessary to explore the distraction produced by in-vehicle touch screens, as well as tactics and initiatives to reduce this distraction to provide a safe driving experience (Jger et al., 2008; Horrey & Lesch, 2009).

In-vehicle touch screens have a lot of benefits, but they also have a lot of drawbacks. Driving is a highly visual activity in which the driver "monitors a continual stream of information as the car travels" (Mourant, 1970, p.81). “Controlling a vehicle takes place in a visually congested environment and includes the simultaneous use of central and peripheral vision and the execution of primary and secondary tasks (both visual and nonvisual),” according to Owsley et al. (2010, p.2352). Poorly designed interfaces provide increased visual distraction, which is one of the main drawbacks of using in-vehicle displays. The more drivers look away from the road and the further away they must look, the more likely it is that vital safety information about the driving environment will be overlooked (Lamble et al., 1999; Horrey et al., 2006). As a result, more complex in-vehicle touch screen designs – with a larger number of buttons, buttons that look similar, too many menu selections, too much information presented at once, and so on – will result in longer task completion times, extending the frequency and duration of glances away from the road (Chisholm et al., 2007).

Another drawback of touch displays is the lack of tactile signals, such as dials and knobs. Whereas with traditional in-vehicle physical controls, drivers might utilise the dials and knobs as tactile cues to interact with the system - potentially without looking - when working with touch displays, this method is more difficult to adopt (McGooking et al., 2008) mainly due to the flatness of the screen. Non-automotive sectors have been borrowing and creating in-vehicle touch technology and interaction styles. Because touch screen interactions outside of the driving environment are often meant to be visually arresting, tactile prompts are unlikely to be necessary for the engagement. However, because driving is a mainly visual activity, the lack of tactile feedback from the touch screen could be a drawback in a driving scenario.

All these additions have the potential to be a distraction while driving. Taking eyes off the road is dangerous, and touch screen interfaces, especially those without haptic feedback, are not conducive to creating "eyes-off" muscle memory. Touch interfaces are not always terrible, but they do allow designers to get away with releasing subpar user experiences.

Mark Webster, an expert on the use of voice in UI and UX design and director of product at Adobe stated that the touch screen provides people a lot more choices in how they develop an interface, which can rapidly lead to complexity. He added that it is distracting and not a pleasant experience to utilise a touch screen in a difficult vehicle like the Navy's. But something like Apple CarPlay or Android Auto brings in an interface that people are already comfortable with, that feels natural and straightforward, and that people are used to using all the time on their phones. That is how it is believed the touch screen interface's design might work well.

4 Ergonomics Issue

In recent years, the appearance of automotive user interfaces has altered dramatically. Because of the seamless integration of interface panels into design surfaces and the usage of touch screens, the number of visible buttons in car interiors is decreasing. Surface integration is aided by active haptic technologies, which provide tactile feedback on smooth surfaces (Lust & Schaare, 2016; Aito, 2018). Despite their potential aesthetic appeal, most touch screens and touch-sensitive surfaces today lack distinct haptic feedback.

Dual-task interference occurs when two tasks are performed simultaneously and require equivalent cognitive, perceptual, or motor resources, according to Wickens' multiple resource hypothesis (Wickens, 2002). Depending on a few factors, including as driving circumstances and driver experience, there may be limited spare visual capacity that can be devoted to secondary touch screen duties while driving. As the spare capacity of the vehicle declines, engagement with in-car displays poses a larger danger of visual distraction to the driver and other road users. Instead of building in-vehicle display interfaces that encourage drivers to look away from the road ahead, systems that allow for the use of peripheral vision should be investigated to reduce visual demand and, as a result, visual distraction. In the context of driving, peripheral vision is critical for capturing and processing information. The foveal region of the eye only looks at a 2° area of the stream of information received from the driving environment at any given time.

Peripheral vision, on the other hand, absorbs a significant amount of information. “The planning of eye movements is partially controlled by information received from the periphery of the eye,” according to the literature (Mourant and Rockwell, 1970, p.81). Mourant and Rockwell (1972) investigated the types and positions of visual signals in driving, the effect of route familiarity on scan patterns, and the differences in information gathering in car following versus open-road driving. The findings of their investigation revealed that peripheral vision is used to detect movement or new information first, then the foveal region is employed for a closer look. Peripheral vision can be used to capture data from inside-the-vehicle screens as well as the driving scene. Following Mourant and Rockwell's (1970) approach, if the information provided on the touch screen can be detected and interacted with using peripheral vision, drivers may be able to engage with the display without taking their eyes off the road. However, this implies that the display should not necessitate the use of the foveal region for closer inspection, and that all necessary information should be collected solely through peripheral vision.

Different automobile manufacturers and automotive suppliers have conducted design studies that show a clear vision of future car interiors and user interfaces. Clean and harmonious interior surfaces dominate concept studies like the BMW Vision iNEXT (BMW Group, 2018), which include not only many layers of functionality (e.g., sensors, lighting, and haptics) but also a wide variety of new materials (metal, wood, and textiles) in user interfaces (Aito, 2018; Preh, 2018; QUAD Industries, 2018). In interaction situations, these so-called "smart surfaces" make it easier to create dynamically responsive and context-sensitive surfaces.

Fig 5. 2021 BMW Vision iNEXT Interior

The interior of BMW's 2018 iNEXT concept car also one of the most intriguing automotive interiors seen in a long time. It considered novel ways for backseat passengers to interact with the vehicle. Touch sensors beneath the seat fabric allow user to trace commands and motions as inputs, and a projector might beam displays over other surfaces. A CEO of Guardian Optical Technologies, Gil Dotan in article ‘Is it time to turn away from touchscreens in our car?’ believes the back seat is the ideal location for a gesture-based UI. "I'm still astonished when people mention it in the context of front-seat passengers. Whereas, you know, the cockpit is meant for the front passengers, mostly the driver. However, getting to the controls from the passenger seat is simple. When you are gazing at the passengers in the back, I believe gesture recognition is crucial. That is where you truly need interface tools and figuring out what they need and how to communicate with them is something that can be done. And it is here that the emphasis should be placed." Dotan elaborated.

5 User Feedback on In-Car Touch Screen Panels

Vehicles are progressively incorporating emerging technologies, such as speech recognition and biometric tracking. Touch screens have been in cars for a long time, but they have only recently been connected to distracted driving. Touch screens, according to study conducted by the University of Utah in collaboration with American Automotive Association (AAA), are increasing the frequency of vehicle accidents on the road. In fact, every single one of the 30 systems tested causes some level of driver distraction especially while driving.

5.1 The Case of Tesla Model S

The Tesla Model S features only a few physical controls, all of which are located on or near the steering wheel. These controls provide access to driving-related functions like as cruise control, autopilot, wipers, and lighting. However, most of the "secondary" amenities, such as the rear-view camera, mobile phone, media player, and climate control, lack physical controls. Instead, the 17-inch touch screen display in the dashboard, between the driver and passenger seats, is the primary means of selecting them. While this is a large screen which is three times the size of an iPad Mini, it cannot display everything. To make things even more confusing, several elements of Tesla's operating system Version 9 are hidden behind an expanded menu.

Fig 6. Tesla Model S Touch Screen Panel

Touch screen dashboards are more flexible than traditional dashboards, but they have one major drawback: there are no haptic feedback. People must gaze at these buttons to reliably press them. Whereas we can learn the location of a physical button and acquire it without paying much, if any, attention to it (and therefore play the piano while reading the score or touch type on a real keyboard), we must visually check the position of a soft button. When soft buttons are concealed underneath menus, selecting them requires multiple touch screen engagements, which takes more time and effort. Time spent with the UI in a car is time spent ignoring the road. Because the controls are located at the bottom of the screen, it takes longer for the eyes to move from the windshield to the menu area, and there is less chance that people will be able to use their peripheral vision to respond to unexpected stimuli on the road while interacting with (and looking at) the touch screen.

6 Haptic Touch Screen and its Effect: Related Past Studies

For its visual-manual instructions simulator test, the National Highway Traffic Safety Administration's (NHTSA) established a 12-second total eyes-off-road time (TEORT) look requirement. This criterion was based on the NHTSA's review of manual radio-tuning data from a simulator study using a 2010 Toyota Prius premium radio and a test-track evaluation of five 2005 to 2010 automobiles with varied radio-tuning control types. However, this 12-second threshold was incorrectly slanted downward. First, in the simulator research, NHTSA oversampled the youngest participants (with the shortest TEORT scores), and in the test track study, NHTSA oversampled the newest radios (with the shortest TEORT ratings). Second, NHTSA wrongly assumed that track and simulator measures were same, although the track TEORT for a matching Prius task with matched older participant ages was much shorter than the simulator TEORT. Third, the NHTSA used the 85th percentile of the TEORT data as its criterion rather than the upper confidence limit; as a result, traditional radio-tuning tasks would fail repeated testing due to random test-to-test variance. After accounting for these and other biases, the current study calculated a threshold of 21.4 seconds using identical NHTSA data sets. According to new research based on naturalistic driving experiments, cumulative look measurements like TEORT have worse predictive value for crashes than other indicators. Based on a developing scientific consensus about the relationship—both positive and negative—between eye glances, relative accident risk, and secondary task performance while driving, a new test with improved predictive validity for relative crash risk should be devised.[10]

Touch screen HMIs (Human-Machine Interfaces) necessitate some visual attention. Some of this need could be eased by using a secondary device in conjunction with a touch screen. Twenty-four drivers used each of four devices — touch screen, rotary controller, steering wheel controls, and touchpad — to execute four typical in-vehicle tasks in a medium-fidelity driving simulator (counterbalanced). During a final 'free-choice' drive, participants were able to mix gadgets. The touch screen was the most preferred/least demanding to use in isolation, based on visual behaviour, driving/task performance, and subjective assessments (workload, emotional response, preferences). The touchpad, on the other hand, was least liked/demanding, while the rotary controller and steering wheel controls were nearly identical in most ways. The rotary controller and steering wheel controls were the most preferred alternatives when given 'free choice,' however this was task dependent. More investigation is needed to investigate these devices in greater depth and over longer periods of time. Touch screen interfaces provide advantages in terms of flexibility and simplicity of interaction, and their use in a variety of devices, from mobile phones to in-car technologies, has grown rapidly. Traditional touch screens, on the other hand, impose an unavoidable visual workload requirement, which has consequences for safety, particularly in vehicle applications. The haptic channel can now deliver feedback thanks to recent advancements in touch screen technology. Using a medium fidelity driving simulator, researchers investigated the impact of visual and haptic touch screen feedback on visual workload, task performance, and subjective reaction. Thirty-six experienced drivers used a touch screen to complete ‘search and select' operations while driving on the highway. The study used a three-by-two within-subjects design, with three degrees of visual feedback: "immediate," "delayed," and "none," as well as two levels of haptic feedback: "visual only," and "visual + haptic." When visual input was delayed or absent, the visual workload rose; however, when haptic feedback was included, the impact was reversed, with no changes in glance time or count. When haptic feedback was activated, task completion time was likewise lowered, although driving performance was unaffected by feedback type. Haptic feedback increased the user experience and lowered perceived task complexity, according to subjective responses.

7 The Changes on Honda Jazz Air Conditioning Controls

While most manufacturers are shifting to touch screen controls, Honda has decided to reinstate heating and air conditioning controls via a dial rather than a touch screen, as seen in the previous-generation Jazz. Jazz 2020 project leader, Takeki Tanaka explained the reason of this changes is straightforward; they wanted to minimise driver disruption especially when adjusting heating and air conditioning control. Takeki also explained, “We changed it from touch screen to dial operation, as we received customer feedback that it was difficult to operate intuitively. You had to look at the screen to change the heater seating, therefore, we changed it so one can operate it without looking, giving more confidence while driving”.

Fig 7. 2015 Honda Jazz (Left) and 2020 Honda Jazz (Right)
Air Conditioning Controller

8 Conclusion

Touch screen panel has been a trend among automotive manufacturer in providing a simple and clean interface on the dashboard. However, drivers are easily struggling and distracting especially when interact with entertainment system or adjusting air conditioning mode. It has a similarity to a distraction when using a smartphone even it is placed on proper hands-free holder because a focus of the driver will be disrupted when they are supposedly focusing on the driving itself. Since modern automobiles are sophisticated computer, it can supplement drivers' cognitive and physical talents with data acquired from a range of sensors and can also improve the driving experience with a myriad of one-tap convenience features. Unfortunately, none of these will be realised until automotive engineers and designers especially working on interior take into consideration decades of experience creating computer interfaces and adhere to well-established usability and human psychology principles. They cannot just follow a trend using touch screen panel and removes all the physical button and switches with assumption user especially drivers will learn to operate the function in a short time, but they need to further improve the application until it was recognizable. There are some features on vehicle such as Autopilot (or self-driving), lane assist, collision detection and other new features have the potential to replace well-learned, traditional driver behaviours such as looking over the shoulder or checking the mirrors. If these features use touch screen panel to operate instead of physical button or switches are functional and easier to use or understand by than the gestures and actions learned when in driving school, they will eventually replace those actions.

This example of touch screen panel issue exemplifies a significant problem that automotive designers and manufacturers are currently confronted with. Some of the function on the dashboard could be easier to switch into haptic touch screen interface but some of it is much better maintain as a conventional tactile control by creating dials or button to interact with the function. Drivers are humans, a creature of minimum effort because they always choose the option that requires the least amount of effort, not because of laziness, but because humans are efficient. Usually we see people applying makeup, playing video games, or even sleeping behind the steering wheel, that was because they feel their vehicle make it appear safe for them. Keep in mind, drivers are having various background and behaviour. Some of drivers had a close interaction with their vehicle as they are depending on their vehicle going to work or generate income (taxi/e-hailing) so features inside a car should assist them while driving. Touch screen panel are going well when in use during stationary condition such as waiting for green traffic light or when standstill in traffic jammed but if it was use while driving when the attention of drivers is highly needed, the risk of road accident cannot be avoided.

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