Confirmation Haptics for Automotive Interfaces

Cadillac CUE User Study

Amaya Becvar Weddle, Senior UX Research Manager
Hua Yu, UX Engineer

immersion

Table of Contents

List of Figures

"For the sake of making better drivers, anything you can do to make people not have to take their eyes off the road is important."

1. Executive Summary

With the wide integration of touchscreens and touch surfaces into modern in-vehicle systems, driver's visual attention is being increasingly taxed. Haptic feedback presents a logical solution for giving drivers tactile response that confirms engagement with the user interface, without requiring users to dedicate as much visual attention. In this original research study, Immersion investigated the end-user value of confirmation haptics as implemented in a commercial vehicle – the 2013 Cadillac XTS, the first commercial implementation of touchscreen haptic feedback.

Immersion conducted a 12-person user study with a 2013 Cadillac XTS vehicle. Users completed basic tasks on the Cadillac User Experience (CUE) interface, such as playing a radio station, changing climate settings, and making a phone call. Following these tasks, participants made ratings about their experience. They also compared the experience with the CUE haptic touchscreen with that of a non-haptic touchscreen, which was simulated using an iPad running the Cadillac CUE app. This app shows the same interface functionality available in CUE without any haptic feedback.

Comparing the ratings of the CUE haptic interface to the interface without haptic feedback showed that participants place high value on haptic feedback in automotive applications. Ratings indicated that haptic feedback made the CUE system easy and pleasant to use, and helped participants feel more confident. Participants were enthusiastic about the inclusion of haptic feedback in an automotive touchscreen, and placed higher value on this feature as compared to audio feedback or high screen resolution.

2. Background: Haptic Feedback in Automotive Interfaces

The modern car offers an increasingly wide array of in-vehicle systems for everyday drivers. Route guidance systems, climate controls, music players, phone, and even online applications are becoming part of the standard automotive interface. Such in-vehicle systems often place high demand on the driver's visual attention, which poses a risk to safety as less eyes-on-the-road time negatively impacts driving performance (Tsimhoni et al., 2001).

Moreover, with the integration of touch interfaces, such as touchscreens, touchpads, and capacitive buttons, the driver is forced to rely less on their sense of touch and spatial memory to find and activate physical controls, and more on their visual sense to confirm that activation of a function has occurred. The driver now has to divide his or her visual attention between the primary driving task and a central information display, which often requires drivers to search through an increasing range of menus to find desired functions.

Haptic feedback presents a logical solution for giving drivers sensory feedback that a function has been activated, with lower visual demands. Several publications demonstrate the value of haptic feedback in automotive interfaces in simulator environments, citing measurable benefits to driving performance (Richter et al., 2010), subjective preference (Pitts et al., 2010, 2011), and visual attention demands (Pitts et al., 2010, 2011).

The 2013 Cadillac XTS is the first commercial implementation of haptic feedback in an automotive touchscreen. In CUE, confirmation feedback is felt when a virtual button is pressed on the touchscreen. There is also haptic confirmation displayed when a user presses a capacitive button on the button panel below the touchscreen. Reviews of the CUE system ranged from positive to lukewarm. Many reviews on the system raised the question as to the user experience impact of perceived latency in the system (Barth, 2012). Immersion embarked on a user study to discover what end-users thought about the addition of haptic feedback to an automotive touchscreen display, or if they preferred a system interface without haptic feedback.

3. Study Design

12 drivers were selected to participate in the study, ranging in age from 20-59. They were gender-balanced and drive daily. 50% of study participants owned vehicles with touchscreens. The remaining participants had used a touchscreen device mounted in their vehicle, such as a GPS or tablet.

The study was conducted with 2013 Cadillac XTS vehicle from a commercial rental agency. This vehicle included the standard market version of the CUE system. The study was conducted inside the rental vehicle, and participants sat in the driver's seat, while a moderator sat in the passenger seat and guided them through a set of tasks. The vehicle remained parked during the test, and the participants operated the touchscreen in order to execute basic tasks, such as changing the radio station, making a Bluetooth phone call, and adjusting the vehicle's temperature.

In order to simulate a touchscreen experience without haptic feedback, we mounted an iPad in the vehicle between the front seats. We used a commercially-available iPad app made by Cadillac that simulates the CUE interface, and had people execute the same tasks on both systems.

Following the task section, participants completed a rating survey about their experience. Finally, they were asked to comment about the consumer appeal of haptic feedback features for automotive touchscreens more generally.

"One thing happened - I missed a telephone # and didn't notice it or why it wasn't making a call. I would have known if I had the feedback."

Figure 1. Cadillac XTS vehicle used in the study.

Figure 2. A participant interacts with the CUE touchscreen.

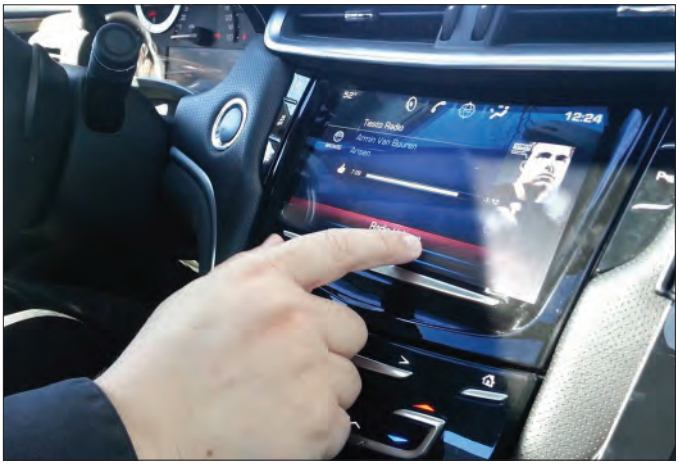


Figure 3. A participant interacts with the iPad CUE app mounted in the vehicle.

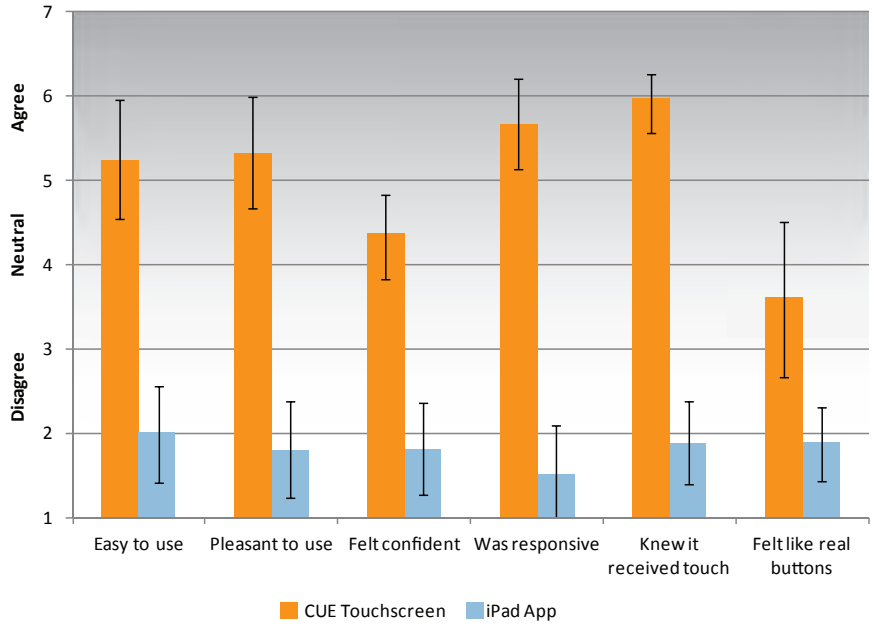
4. Study Findings

4.1 Study Findings: Haptics Improves the User Experience

"It felt natural. I was not focused on it, I was focused on navigating the screen. It was seamless."

Participants' ratings indicate that they found haptic feedback to be a valuable component of the touchscreen operation in an automotive application. As shown in Figure 4, all rating comparisons were substantially different between the haptic and no haptic (iPad) conditions. Users indicated that they found the CUE Touchscreen with feedback to be easier and more pleasant to use. Haptic feedback gave them more confidence that the system had received their touch. This result was especially significant considering that the display resolution and touch response of the iPad was far superior in the iPad condition, as compared to the performance and resolution in the CUE touchscreen. It appears that the importance of having haptic feedback outweighed some of the processing speed and visual fidelity of the iPad system.

Figure 4. Mean ratings data for all participants for the CUE (haptic) and iPad (no haptic) study conditions. Error bars represent 95% confidence intervals.



Participants' verbal comments supported the valuation of haptic feedback expressed through the ratings surveys.

"It felt natural. I was not focused on it, I was focused on navigating the screen. It was seamless." (Study participant, describing the CUE touchscreen)

"One thing happened - I missed a telephone # and didn't notice it or why it wasn't making a call. I would have known if I had the feedback." (Study participant, describing the iPad condition)

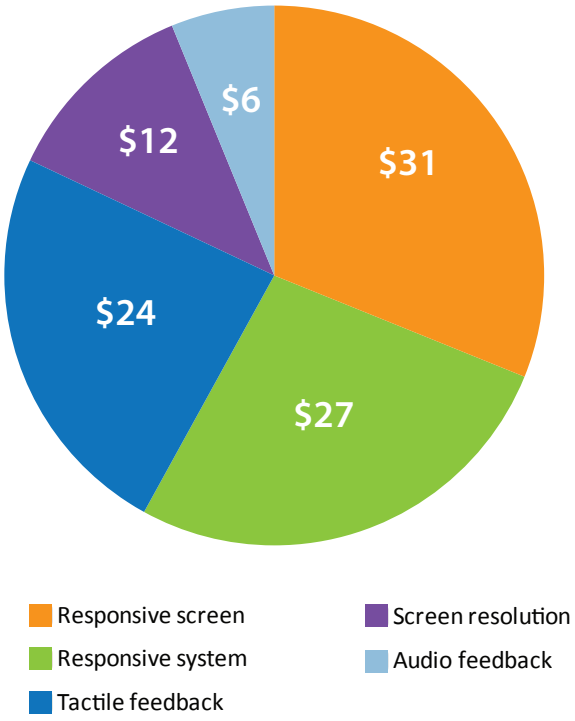
"The system is a lot easier to control with tactile feedback. A lot of times they just want to include a feature just to include it. That's not the case with haptics."

4.2 Study Findings: Users Value Haptic Features

At the end of the test session, participants were asked to evaluate the value of haptic feedback compared to other touchscreen features. They were asked to distribute a pot of $100 amongst the following features that might be in a car touchscreen: a responsive screen, a responsive system, high screen resolution, audio feedback, and haptic feedback. They were instructed to allocate more money to features that hold high value to them, and less money to features that are less important.

Figure 5 indicates that participants most highly valued a responsive screen and vehicle system (e.g. how fast the fan speed increased after user input was received). Third most valued feature was haptic feedback, with twice as much money allocated than screen resolution. Verbally, many participants' commented that screen resolution was not as important to them, because they did not intend to look closely at the screen. One participant remarked, "I don't need a high resolution screen, I'm not going to watch movies on it. Pretty graphics are not so important, big sized buttons are." Finally, compared with audio feedback, participants placed nearly 4 times as much value on haptics. As one participant noted, "When I'm driving, I hear lots of things - music playing, my dog barking. I can rely on my touch senses much more than my hearing. Feeling feedback through my fingers lets me focus my attention there."

Figure 5. Average dollar amounts allocated by participants from a fictitious $100 pot towards possible touchscreen features. Features with more dollars allocated hold higher value to participants.



5. Conclusions

Comparing the ratings of the CUE haptic interface to the interface without haptic feedback showed that participants place high value on haptic feedback in automotive touchscreen applications. Ratings indicated that haptic feedback made the CUE system easy and pleasant to use, and helped participants feel more confident. Participants were enthusiastic about the inclusion of haptic feedback in an automotive touchscreen, and placed higher value on this feature as compared to audio feedback or high screen resolution.

An interesting finding to note is the striking difference of ratings for responsiveness between the CUE and the iPad touchscreens. Even though the iPad touchscreen has an objectively faster screen response due to a better processor and more optimally engineered touch system, the users gave the CUE touchscreen a much higher score for responsiveness (5.7 versus 1.5). It appears that haptic feedback can influence perceived responsiveness of a touch system, even one with inherent latency. It would be interesting to do further research to understand how haptic feedback might be able to alleviate some of the negative impacts of system latency.

There were some limitations to this study that should be noted. This was a small-scale study, conducted with only 12 individuals, and driving performance was not measured. In the future, more work should be done to expand upon the literature that demonstrates safety, as well as consumer preference, for haptic-enhanced automotive touchscreens.

Moreover, touchscreens are capable of recognizing a variety of touch interactions beyond simple press. The CUE touchscreen design applies haptic feedback in the same way for a simple click, as well as almost all the recognized gestures (swipe, etc.). More work should be done to better understand how to expand the effect set to give the user richer information about the results of these complex touch gestures. Haptics can potentially allow a user to distinguish one kind of touch interaction from another. Understanding how to create intuitive design patterns supported by haptic feedback, and how these improve driving safety, is an important line of future research.

"When I'm driving, I hear lots of things - music playing, my dog barking. I can rely on my touch senses much more than my hearing. Feeling feedback through my fingers lets me focus my attention there."

6. References

Tsimhoni, O., and Green, P. (2001). "Visual Demand of Driving and the Execution of Display-Intensive, In-Vehicle Tasks." Proceedings of the Human Factors and Ergonomics Society, 45th Annual Meeting.

Barth, L. (2012). "New Cadillac CUE Infotainment System Frustrates." Nov. 21, 2012. http://news.consumerreports.org/cars/2012/11/new-cadillac-cue-infotainment-system-frustrates.html

Richter, H., Ecker, R., Deisler, C., Butz, A. (2010) "HapTouch and the 2+1 State Model: Potentials of Haptic Feedback on Touch Based In-Vehicle Information Systems." Automotive UI'10, Nov. 11-12, Pennsylvania.

Pitts, M., Burnett, G., Williams, M., Wellings, T. (2010) "Does Haptic Feedback Change the Way We View Touchscreens in Cars?" ICMI-MLMI '10, Nov, 8-10 China.

Pitts, M., Burnett, Skrypchuk, Wellings, Attridge, Williams. (2011) "Visual-haptic feedback interaction in automotive touchscreens." Displays, 33(1) 7-16.

About Immersion

Founded in 1993, Immersion is the leading innovator in haptic technology; the company's touch feedback solutions deliver a more compelling sense of the digital world. Using Immersion's high-fidelity haptic systems, partners can transform user experiences with unique and customizable touch feedback effects; excite the senses in games, videos and music; restore "mechanical" feel by providing intuitive and unmistakable confirmation; improve safety by overcoming distractions while driving or performing a medical procedure; and expand usability when audio and visual feedback are ineffective. Immersion's TouchSense technology provides haptics in mobile phone, automotive, gaming, medical and consumer electronics products from world-class companies. With over 1,300 issued or pending patents in the U.S. and other countries, Immersion helps bring the digital universe to life. Hear what we have to say at blog.immersion.com.

For additional information about tactile feedback, haptics, and the human response to specific haptic effects and performance parameters, contact Immersion at focus@immersion.com.

Many consumer studies and whitepapers are also available on Immersion web site. To access and download these documents, please visit http://www.immersion.com/whitepapers

immersion.com | +1 408.467.1900 | 30 Rio Robles | San Jose, California 95134

Lit#Confirmation-Haptics_CUE-study.Jun13.v1