Haptic-Payment: Stimulating ‘Pain’ of Payment through Vibration Feedback in Mobile Devices

Abstract
The proliferation of mobile payment applications in recent years has further decoupled the physical act of paying from the consumption experience. Prior research suggests that this decreases the psychological ‘pain’ that consumers feel when making a purchase, and leads them to spend more money than they otherwise would. The present research proposes a system that restores the physical sensation of paying to mobile payment apps. Drawing on a preliminary user study, as well as prior theories on prehensile grip types and haptic vibration feedback thresholds, we develop a device consisting of an array of vibration motors that can be attached to the back of a mobile phone and can be controlled through a custom application to provide vibration feedback of varying frequencies and durations at the time of mobile payment. Our preliminary findings suggest that a configuration of vibration motors located around the right and left edges of the phone, and which give high frequency, short duration vibrations upon payment is the most effective way inducing the pain of payment.

Author Keywords
Mobile payment; consumption experience; haptic feedback.

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous
Introduction & Background

With the introduction of mobile payment apps such as Apple Pay, Google Pay, Samsung Pay, and Microsoft Wallet, consumers have more options than ever to make seamless purchases [3, 15, 8]. Not only do several large retailers accept payments from these third party apps, they also offer their own form of mobile payment, and in some cases, they no longer accept cash payments at all [18]. For instance, the Walmart Pay app allows customers to scan, store, and purchase items in-store without a need to go through a physical check-out. Given the convergence of both consumer and retailer interest, it is perhaps not surprising that the number of consumers using mobile payment options is projected to grow from 55 million in 2018 to almost 75 million in 2022 [3].

Despite the greater convenience of mobile payment versus more traditional methods (i.e., cash), past work suggests that its proliferation may have a negative impact on consumers' financial well-being by inducing them to spend more. In particular, prior research has found that because cashless payment methods decouple the physical act of paying from the consumption experience, they reduce the amount of psychological 'pain' that consumers feel when parting with their money [16, 19]. As a result, studies have found that consumers who pay with cashless methods spend more on purchases than those who pay with cash [17]. For example, Prelec and Simester [17] showed that consumers paid more for sports tickets when they used a credit card (vs. cash). Given that mobile payment requires even less effort from the consumer than using a credit card, it is likely that this method further induces consumers to spend. Thus, it appears that the growth in mobile payment will only exacerbate existing consumer debt levels, which reached $13.3 trillion in 2018 [1]. To address this issue, the current project explores a mobile phone design that recouples mobile payment apps with the pain of payment.

In particular, drawing on prior work suggesting that vibration feedback can act as a non-conscious sensory prime of negative emotions [5, 6, 12], we propose a haptic interface consisting of an array of vibration motors that can be directly attached to a mobile device to simulate the pain of payment.

Additionally, drawing on studies showing that vibration perception thresholds are lowest near the fingertips [14], as well as when there is greater contact area [13], we propose that the most effective interface will consist of an array of vibration motors, one at each point where consumers are most likely to grip the phone. While haptic feedback can be found in most smartphones, they are limited to a small range of vibrations due to lack of standards in manufacture...
hardware (e.g., Samsung, HTC, Google, etc...). Our system is designed to increase the range of vibrations available in smart phones and provide a more rich haptic interface.

In summary, our contributions are as follows:

- A system designed for coupling physical payment feedback with consumption via mobile payment apps;
- A preliminary investigation of consumer phone grip when interacting with mobile payment apps;
- Provide an initial understanding of preferred types of haptic vibration feedback in association with mobile payment apps; and
- A working prototype designed based on consumer phone grip and vibration preferences that can be integrated into existing phones.

In the next section, we describe a preliminary user study that we ran in order to better understand how consumers interact with their mobile device during payment. In particular, we investigate how consumers grip their devices while interacting with a payment app in order to inform the placement of the vibration motors. Further, we look at consumer preferences regarding the strength and duration of haptic vibration feedback during mobile payment.

**Preliminary User Study**

We surveyed 151 adults (47% female, mean age = 35) to better understand how consumers interact with their mobile devices while using a mobile payment application. In particular, we wanted to analyze how consumers grip their phones while interacting with the mobile payment app in order to inform the placement of the vibration motors. Further, we look at consumer preferences regarding the strength and duration of haptic vibration feedback during mobile payment.

A majority of the participants in our study reported being right-hand dominant (85%). Additionally, most participants reported having used a mobile payment app in the past (59%). In order to develop a better understanding of how consumers grip their mobile device, we asked them to imagine the following scenario: “You are at a store and are using a mobile payment app to pay for the items that you have scanned into your digital shopping cart. You are about to press the PAY button on the app. Take a moment to think about how you would hold your mobile phone in your hand while interacting with the mobile payment app. On the pictures below, please click the areas of the phone (front and back) to show where you would grip the phone while interacting with the mobile payment app.”. Participants were then shown a picture of the front and back of an iPhone 10, and clicked to indicate the locations they would be most likely to grip the phone. A heat map analysis revealed that participants were most likely to grip the phone in the middle of both edges with additional contact along the center of the back side of the phone (see figure 3). This suggests that consumers using mobile payment tend to cradle their device in their palm while grasping it on the edges with their fingers and thumb [7, 2, 10, 4].

Next, we asked participants several additional questions regarding how they would perceive several types of vibration feedback. We first asked them about their preferred vibration type for payment notifications: Q1: “Would you prefer a weak (low frequency) or strong (high frequency) vibration for the mobile payment app to notify you that money has been removed from your account?” (1 = weak; 5 = strong); and Q2: “Would you prefer a short duration vibration or a long duration vibration to notify you that money has been removed from your account?” (1 = short; 7 = long).

Next, we asked participants to indicate which vibration type they would prefer to feel when pushing the PAY button in
the mobile payment app (weak/short duration, weak/long duration, strong/short duration, strong/long duration). Finally, we asked participants to indicate which vibration type they would feel the most "painful" upon pushing the payment button (weak/short duration, weak/long duration, strong/short duration, strong long duration).

A subsequent analysis revealed that participants preferred strong (high frequency) vibration feedback to notify them of a payment ($M = 3.39$ out of $5, SD = 1.28$). They further preferred short vibration duration ($M = 2.84$ out of $5, SD = 1.28$). Next, of the four vibration types, the strong/short duration vibration was preferred by the most participants ($n = 69$), whereas the weak/short duration vibration was chosen by the second most participants ($n = 42$). Finally, the majority of participants indicated that the strong/long duration vibration would be the most painful ($n = 101$), see figures 1, 2, 4, and 5. This final result is particularly interesting, as it indicates that participants preferred vibration feedback (strong/short duration) is not the one that elicits the greatest feelings of pain of payment.

Design Motivations

To motivate our design, we drew on our preliminary user study, as well as prior theories on prehensile grip types [7, 2, 10, 4] and haptic vibration feedback thresholds [14, 13]. In particular, our user study indicated that consumers grip the phone around the edges with their fingers while cradling it in the palms. This finding is consistent with the grip interaction outlined by [7, 2, 10, 4]. Our choice of vibration motors as the source of haptic feedback was motivated by prior research indicating that people readily associate vibration with negative emotions or things that should be avoided [5, 6, 12]. Thus, we propose that vibration should be perceived as unpleasant or 'painful' when associated with the act of paying in a mobile application. Considering that consumers grip their device around the edges, as well as that vibration perception thresholds are the lowest near the fingertips [14], and when there are multiple contact points [13], we concluded that placing multiple vibration motors near the edge of the phone would best allow consumers to sense vibration frequencies associated with mobile payment.

Hardware & Software Implementation

The add-on haptic-payment controller device is designed to be attached to the back of most smart phone devices. This controller has the capability to connect to the phone via Bluetooth or Wi-Fi. The hardware is composed of five vibration motors, five haptic controllers (to control vibration intensity of motors), ESP32 Wi-Fi/Bluetooth micro-controller, and lithium ION battery. Our current design is housed in a custom-made 3D printed case which also includes an enclosure to protect the user from accidentally touching the circuitry. Figure 7 shows the inner workings of our current prototype. Our current mobile app user-interface is made of 3 screens to control Haptic-payment controller while allowing user to purchase items (see figure 6). The following is a list of available actions that can be performed in current app:

- Haptic Settings: Allows to turn on/off the haptic system and set vibration intensity & pattern combination of both vibration motors;
- Shopping Cart: Allows the user to keep track of his current items, and checkout or remove items if needed; and
- Scanner: Allows the user to scan items by locating QR code.

Conclusion & Future Work

In the present research, we develop a system to simulate the psychological 'pain' of payment in mobile payment applications. Leveraging feedback from a preliminary user study, as well as prior theories on prehensile grip types [7, 2, 10, 4] and haptic vibration feedback thresholds [14, 13], we conclude that placing multiple vibration motors near the edge of the phone would best allow consumers to sense vibration frequencies associated with mobile payment. Future work will involve testing this system with a larger sample size to validate our findings and explore potential ways to personalize and customize the vibration feedback to better align with individual user preferences.
study, as well as prior theory regarding mobile device grip styles and user perceptions of haptic vibration feedback, our system consists of an array of vibration motors that can be placed at specific locations on the phone where the user’s hand comes into contact with the mobile device. We further create a custom application that controls the frequency and duration of the vibration in the motors. Preliminary findings indicate that strong vibrations with long duration create the most psychological pain when paying with a mobile, however, this is not the vibration type that is most preferred by consumers. Thus, further user studies are needed to determine the best vibration feedback to simulate pain of payment, while not being overly aggravating or annoying to users. Additionally, given the future possibility that our system will use different types of vibration feedback depending on the amount being paid, further studies are needed to determine the precise placement of motors that will allow users to perceive different vibration frequencies (i.e., where are the thresholds lowest for detecting a change in vibration frequency). Future studies will be run in a simulated retail environment where participants will scan items from a display into their smartphone and check them out. Also, with the increase use of wearable devices (e.g., smart watches) for mobile payment, we will further investigate how to stimulate the sensation of payment through other devices beyond smart phones. Further studies will help understand how consumers behave in these emerging intelligent retail stores and how new and novel interfaces can be designed to help consumers maintain awareness of their spending and personal finance digitally [11].

REFERENCES


