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Haptic-payment: Exploring vibration feedback as a means of reducing overspending in mobile payment

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ABSTRACT
The proliferation of mobile payment applications in recent years has decoupled the physical act of paying from the consumption experience. Prior research suggests that this decreases the psychological sense of loss or ‘pain’ that consumers feel when making a purchase with more direct payment types (such as cash) and leads them to spend more money. To help address this issue, the present research explores, designs, and tests haptic vibration feedback configurations aimed at restoring the ‘pain’ of paying with cashless payment options (i.e., online and mobile payment). Counter-intuitively, the present research finds that lower- (vs. higher-) intensity vibration feedback reduces participants’ reported willingness-to-spend when compared to a control group that does not receive any vibration feedback. This work is one of the first to explore the role of haptic vibration feedback in nudging consumers to reduce their spending when using cashless payment methods.

1. Introduction
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 (Chadha, 2015; Kim, Mirusmonov, & Lee, 2010; Lehdonvirta, Soma, Ito, Kimura, & Nakajima, 2008). 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 (Pritchard, Vines, & Olivier, 2015). For instance, the Walmart Pay app allows customers to scan, store, and purchase items in-store without the 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 (Chadha, 2015). The recent Covid-19 pandemic has accelerated this trend, as the percentage of cashless sellers jumped after March 2020 (Poon, 2020).

Past work suggests that the proliferation of mobile payment may have a negative impact on consumers’ financial well-being by inducing them to spend more. Specifically, prior research has found that because cashless payment methods decouple the physical act of paying from the consumption experience, they reduce the sense of psychological loss or ‘pain’ that consumers feel when parting with their money (Prelec & Loewenstein, 1998; Raghubir & Srivastava, 2008). As a result, studies have found that consumers who pay for everyday purchases (e.g., groceries) with cashless methods, such as credit card, spend more on such purchases than those who pay with cash (Prelec & Loewenstein, 1998; Prelec & Simester, 1998). 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 (Tatham, 2019).

How might human-computer interaction (HCI) and consumer researchers approach this issue? The rich literature exploring the role of multisensory design in consumer technologies offers several insights. Studies in this area suggest that combinations of haptic and visual feedback delivered via mobile devices can effectively influence consumers’ responses to stimuli and events (e.g., Hadi & Valenzuela, 2019; Lee, Polakoff, & Spence, 2009; Lee & Spence, 2008a, 2008b). For instance, Hadi and Valenzuela (2019) found that pairing mobile message prompts with haptic vibration alerts improved consumers’ responsiveness to the messages due to increased feelings of social presence.

In line with this prior work, the present research investigates whether pairing haptic vibration feedback with cashless payment options (such as a mobile app) can restore the psychological sense of loss that consumers associate with more tangible forms of payment (Prelec & Loewenstein, 1998). More specifically, this work explores the...
effectiveness of different vibration feedback intensities in limiting participants’ reported willingness-to-spend compared to a no-feedback condition control. A pre-test finds preliminary evidence that consumers are more likely to associate a cashless payment with loss when they receive lower-intensity vibration feedback during payment, compared to a no-feedback control condition. On the other hand, they are not significantly more likely to associate a cashless payment with loss when they receive higher-intensity vibration feedback (versus the no-feedback control). Consistent with this observation, a follow-up study finds evidence that lower-intensity vibration feedback can reduce consumers’ willingness-to-spend with a cashless payment method in a simulated retail setting when compared to a no-feedback control condition. By contrast, higher-intensity vibration feedback does not significantly reduce consumers’ willingness-to-spend versus the no-feedback control. It is theorized that these results occur because people associate lower-intensity vibration with negative and low arousal emotions and, thus, more readily associate cashless payments with loss when these payments are paired with lower-intensity vibration feedback.

The findings of this research have both theoretical and practical implications. First, whereas prior research has shown that ‘pain’ of payment is attenuated when consumers use cashless methods (Prelec & Loewenstein, 1998; Prelec & Simister, 1998), there has been little work exploring how such cashless payment methods can be modified to create this psychological sense of loss. By leveraging existing knowledge of multisensory design in consumer technology (e.g., Lee et al., 2009; Lee & Spence, 2008b; Spence, 2002), this work is the first to propose a non-intrusive way to shape consumers’ perceptions of cashless payment by using technology already found in most mobile devices. Next, recent work in the consumer literature has begun to explore the joint effect of visual and vibrotactile feedback in nudging consumers towards desired actions (e.g., Hadi & Valenzuela, 2019). This work has primarily focused on the role of multisensory feedback in stimulating positive behaviors – i.e., inducing consumers to pursue a goal. By contrast, the current work explores visual and vibrotactile feedback as a means of discouraging negative consumer behaviors, such as overspending. By finding that providing such feedback can act to discourage certain consumer actions, this work extends research on multisensory design as a means of providing negative feedback (Faust & Yoo, 2006; Ho, Reed, & Spence, 2006; Jiang, Girotra, Cutkosky, & Ulrich, 2005). Finally, although prior work has explored vibration intensity in order to determine at what thresholds people can detect different frequencies (e.g., Morioka & Griffin, 2005; Oey & Mellert, 2004), HCI researchers are only beginning to explore how vibration intensity affects people’s psychological responses (Abdullah, Hassan, Raza, & Jeon, 2018; Yoo, Yoo, Kong, & Choi, 2015). Some consumer work has explored responses to differing frequencies of auditory feedback (Lowe, Loveland, & Krishna, 2018), but consumer studies using haptic feedback have only used a single vibration intensity (Hadi & Valenzuela, 2019). Thus, to the best of our knowledge, this study is the first to find that differences in vibration intensity feedback can affect consumption behavior. This finding has especially important implications for practitioners, as the range of vibration intensities that can be accessed through mobile software development kits (SDKs) and associated application programming interfaces (APIs) are limited due to a lack of standards in manufacturer hardware.

2. Theory and hypotheses

2.1. Multisensory design for consumer technologies

Different sensory modalities interact with one another to influence people’s perception of stimuli and events (Calvert, Spence, & Stein, 2004). Consumer researchers have leveraged this observation to investigate the joint effect of haptic (touch) and visual feedback on consumer evaluations and responses (for a review see Spence & Gallace, 2011). These studies have found that differences in the texture, weight, temperature and hardness of objects influences consumer evaluations of these objects (e.g., Klatzky, Lederman, & Matula, 1991; Peck & Childers, 2003a, 2003b; Peck & Wiggins, 2006). For instance, Krishna, Elder, and Caldara (2010) demonstrated that consumers perceived rough-textured paper as more masculine than smooth-textured paper, which they perceived as more feminine.

Relatively, a large body of literature has explored technology-mediated haptic feedback, or haptic feedback that comes from devices such as mobile phones and wearables (e.g., Brewster & Brown, 2004; Brown et al., 2006; Brown & Kaaresoja, 2006; Haans & Usselteijn, 2006; Haans et al., 2014; Kaaresoja & Linjama, 2005; Lee et al., 2009; Lee & Spence, 2008a, 2008b). Early studies in this area investigated optimal multisensory design for technology using haptic and visual feedback (Brewster & Brown, 2004; Brown et al., 2006; Lee & Spence, 2008a, 2008b). For instance, Lee and Spence (2008a) investigated the optimal timing of visual and vibrotactile feedback to create perceptions of synchrony between the two modalities. Building on this work, consumer studies have begun to explore consumers’ interaction with mobile devices (e.g., Brasel & Gips, 2014; Hadi & Valenzuela, 2019; Petit, Velasco, & Spence, 2019). For instance, Hadi and Valenzuela (2019) found that vibration feedback makes consumers more responsive to mobile messages that appear on a touchscreen. Notably, most of these studies have tended to focus on the positive consequences of pairing vibration feedback with visual stimuli. However, vibrotactile feedback has also been paired with visual stimuli to activate more negative emotional responses, such as feelings of discomfort or danger (Faust & Yoo, 2006; Ho, Reed, & Spence, 2006; Ho, Tan, & Spence, 2005; Spence & Driver, 1999; Ho et al., 2005; Jiang et al., 2005; Mahmud, Saha, Zafar, Bhuian, & Sarwar, 2014). For instance, studies have demonstrated the effective use of vibrotactile cues as warning signals for visual hazards in driving tasks (Ho et al., 2006; Ho, Spence et al., 2005; Ho, Tan et al., 2005). Similarly, research has shown vibration feedback to be a useful tool for training military and emergency responders how to avoid certain visual obstacles in a virtual reality simulation (Jiang et al., 2005). The next section further builds on the notion that vibrotactile feedback can elicit negative emotional responses when paired with certain stimuli in order to theorize how it might prompt psychological feelings of loss when paired with cashless payment methods.

2.2. Haptic vibration feedback and ‘Pain’ of payment

Cashless payment options, such as credit cards and mobile pay, decouple purchases from the physical act of handing over one’s money (Gourville & Soman, 1998; Soman & Gourville, 2001). As such, prior work has found that consumers experience lower psychological feelings of loss or ‘pain’ of payment when using cashless payment options and, as a result, are more likely to overspend (Prelec & Loewenstein, 1998; Prelec & Simister, 1998). For example, Prelec and Simister (1998) showed that consumers paid more for sports tickets when they used a credit card, as opposed to cash.

Given the aforementioned findings that people can perceive vibrotactile feedback as a negative prompt when paired with certain visual cues (e.g., Ho, Tan et al., 2005; Jiang et al., 2005), the present research seeks to understand whether vibration feedback can similarly work as a negative prompt when paired with cashless payment options. More specifically, the present research is interested in whether vibration feedback can restore the psychological sense of loss or ‘pain’ that consumers tend to experience when paying with actual money. If this is the case, consumers who receive vibration feedback when making a cashless payment should spend less versus those who do not receive vibration feedback.

How might this process work in a cashless payment context? Prior research indicates that vibration feedback can help direct consumers’ visual attention towards an object or stimulus, especially when the vibration comes from the spatial location where the object is located (e.g., Spence, Nicholls, Gillespie, & Driver, 1998; Spence, Shore, & Klein,
Consistent with these findings, studies have found that vibrotactile feedback improves task performance for activities that require high levels of attention on mobile devices (Brewster, Chohan, & Brown, 2007; Lee et al., 2009; Prewett, Elliott, Walvoord, & Coover, 2011). For instance, research shows that providing tactile feedback on touchscreen keyboards leads users to enter more text while making fewer errors (Brewster et al., 2007). Therefore, it stands to reason that pairing vibration feedback with a cashless payment should increase consumers’ visual attention to the payment transaction. This should be especially true for mobile payments, as the vibration coming from the mobile device will direct consumers’ visual attention to the device itself and, therefore, to whatever action they are taking with it to make the payment—e.g., pushing a payment button in an app or swiping the device over a scanner.

However, in addition to merely directing attention towards the spending, this research further posits that properties of the vibration feedback itself will affect perceptions of the cashless payment. We specifically focus on vibration intensity, or the speed of the vibrating motor expressed in units of millimeters per second (mm/s) (Centre, 2018), which affects people’s sense of magnitude or strength of the vibration (Hwang, Seo, & Choi, 2017). Vibration intensity-level is operationalized in relative terms, with higher-intensity vibration as the setting where the motor is set to 100% capacity and lower-intensity as the setting where the motor is set to 60% capacity (the specific vibration measurements for each of these settings are detailed in the studies).

How might relative vibration intensity-levels influence consumers’ perceptions of making a cashless payment? Prior work suggests two possibilities. On one hand, consumers might perceive higher-intensity vibrations as more annoying or startling than lower-intensity vibrations (Chang & O’Sullivan, 2005; Manshad, Brannon, Alharthi, & Iyer, 2019; Seifi & Maclean, 2013). For instance, participants have reported being more alarmed by higher-intensity vibration notifications (Seifi & Maclean, 2013). On the other hand, a larger body of literature has found that people associate lower-intensity haptic cues with negative information. Specifically, several studies have demonstrated people to associate lower-intensity vibrations with negative and low arousal emotions, such as sadness (Abdullah et al., 2018; Yoo et al., 2015; Yoo, Hwang, & Choi, 2014). For instance, Yoo et al. (2015) demonstrated that tactile icons on a mobile phone elicited more negative emotions when set to lower- versus higher-intensity vibration. In line with these latter findings the present research proposes that, compared to a no-feedback control condition, pairing lower- (vs. higher-) intensity vibration feedback with payment cues will be most effective at associating a cashless payment with a psychological sense of loss. As a result, this research posits that consumers who receive lower-intensity vibration feedback while making a cashless payment should be less willing to spend.

The next section presents a pre-test, whose main purpose was to look for preliminary evidence for the theoretical proposition that lower-intensity vibration feedback is most likely to increase participants’ perceptions of monetary loss associated with a cashless payment relative to a no-feedback control condition.

3. Pre-test: Does vibration intensity affect perceived ‘pain’ of payment?

Participants engaged in an online shopping task where they imagined purchasing an item from an e-commerce checkout page, which the researchers developed for the purposes of this study. The page was designed so that when participants pressed the ‘purchase’ button on the page, a ‘processing purchase’ visual prompt appeared on the screen. In the treatment conditions, this prompt was accompanied by differing levels of haptic vibration feedback via a handheld device that was also designed by the researchers (this device is further detailed in the next section). The duration of the haptic feedback in both treatment conditions was 1000 ms (ms). Following the task, participants answered several questions about their perceptions of making the payment.

3.1. Method

3.1.1. Hardware and software implementation

The researchers created an add-on Internet-of-Things (IoT) device, which is subsequently referred to as the haptic-payment controller. The haptic-payment controller was designed to both be held by itself, as well as to be attached to the back of most smart phone devices. This design was meant to be consistent with configurations found in other work that has investigated haptic feedback in mobile contexts (Abdullah et al., 2018; Hwang et al., 2017). The haptic-payment controller has the capability to connect to the mobile phone via Bluetooth or Wi-Fi. The hardware is capable of controlling an array of vibration motors via a dedicated feedback module (to control vibration intensity of motor). However, the studies in this research only utilized a single vibration motor (10 mm diameter × 2 mm width, voltage 2 V–5 V). The device also contains an ESP32 Wi-Fi/Bluetooth micro-controller, and lithium ION battery and internal charger when connected to a USB port. The current design is housed in a custom-made 3D printed case which also acts as an enclosure to protect the user from accidentally touching the circuitry. Appendix A shows the inner workings of the current prototype.

The researchers also created a custom N-tier (i.e., multiple layer) web-application to control the haptic-payment controller. This application is powered by the Microsoft Azure cloud. Notably, the web-application uses a standard responsive HTML framework called Bootstrap that is mobile-first—i.e., it conforms the UI components consistently across all resolutions and screen sizes. Across both the pre-test and the main study, the application allowed the researchers to create e-commerce interfaces that participants could interact with (these are detailed in the subsequent study design sections) and to set vibration-intensity levels on the motor. The vibration level for participants in the lower-intensity condition was set to 60% of the motor’s capacity, whereas the vibration level for participants in the higher-intensity condition was set to 100% of the motor’s capacity. According to vibration-meter (Model: VM6310) measurements of the motor, this was equivalent to an average velocity of 0.63 mm/s in the lower-intensity condition and 1.56 mm/s in the higher-intensity condition.

3.1.2. Design and participants

Sixty undergraduate participants (M age = 22 years, female = 55%) from a public university were recruited for this study in exchange for a small monetary compensation and randomly assigned to one of three experimental conditions (vibration intensity: control vs. lower-intensity vs. higher-intensity). This resulted in a between-subjects design with 21 participants in the control condition, 18 participants in the lower-intensity condition, and 21 participants in the higher-intensity condition. The materials for this pre-test were approved by the university’s Institutional Review Board and informed consent was gathered from all participants.

Upon recruitment, participants were told that the experimenters were interested in their perceptions of paying for products online. Upon being seated, participants were handed the haptic-payment controller and asked to cradle it in the palm of their non-dominant hand, or the hand that they would not typically use to operate a computer mouse. In order to maximize participants’ contact with the vibration motor and, thus, ensure that they noted the vibration intensity accurately, they were further instructed to grasp the vibration motor in-between their thumb and middle finger (see Appendix B).

Participants were then shown a fictional e-commerce website that was created for this study. The interface consisted of a virtual shopping cart check-out page containing a $60 computer desk and a functioning ‘purchase’ button that prompted a payment processing pop-up notification when clicked (see Appendix C for screenshots of the e-commerce application). Participants were asked to imagine that they had been
Although the one-way ANOVA is non-significant, Hsu (1996) suggests that participants in the lower-intensity vibration condition associated the payment with greater feelings of loss compared to participants in the control condition ($M_{\text{lower}} = 4.76$ ($SE = 0.34$), $M_{\text{control}} = 3.78$ ($SE = 0.31$); $t(57) = 2.14$, $p = .03$). By contrast, participants in the higher-intensity vibration condition did not associate the payment with significantly greater feelings of loss compared to participants in the control condition ($M_{\text{higher}} = 4.35$ ($SE = 0.31$), $M_{\text{control}} = 3.78$ ($SE = 0.31$); $t(57) = 1.30$, $p = .17$) (see Fig. 1). Notably, the focal contrast between participants in the lower-intensity and control conditions remained significant when gender and age were included as covariates in subsequent t-test comparisons with Dunnett’s adjustment ($p = .01$) (see Appendix D for additional detail on comparisons with covariates included). Finally, although not central to the predictions of this research, an additional analysis tested whether vibration intensity interacted with participants’ scores on the Need-for-Touch scale and found that it did not ($p = .54$).

3.3. Discussion

In the pre-test, participants who received lower-intensity vibration feedback while making an online payment reported greater perceptions of monetary loss relative to participants in the no-feedback control condition, whereas participants in the higher-intensity condition did not differ from those in the control condition. This finding provides preliminary support for the theoretical assertion that lower-intensity vibration feedback is most effective at provoking a sense of monetary loss when associated with a cashless payment. The next study leverages this theoretical insight into a practical examination of whether lower-versus higher-intensity vibration feedback is most effective at limiting consumers’ willingness-to-spend for cashless mobile payments compared to a no feedback control group.

4. Main study: Can vibration feedback influence spending in a retail environment?

The main study sought to test the effect of vibration feedback on participants’ willingness-to-spend in a simulated retail setting. For this study, the researchers created a new mobile payment application that included QR code scanning capabilities and a functioning shopping cart, so that participants could scan items on a retail shelf. The application communicated with the haptic-payment controller when participants pushed the ‘purchase’ button and could wirelessly make the motor vibrate at different intensities, similar to the application in the pre-test. Notably, to facilitate the mobile nature of the study, the haptic payment controller was connected to the back of a mobile phone, which all participants used (see Appendix E). Further, because the design of the haptic-payment controller allowed us to change the position of the motor, two different motor location configurations were tested—one at the edge of the phone and another in the middle of the phone. Although this manipulation was not part of the formal hypothesis, we were interested in whether the location of vibration feedback influenced participants’ responses to the vibration. This interest was motivated by prior studies showing evidence that peoples’ thresholds for detecting vibration are lower near the fingertips than near the palms (Morioka & Griffin, 2005; Oey & Mellert, 2004).

4.1. Method

4.1.1. Hardware and software implementation

As previously discussed, the haptic-payment controller from the pre-test was used for this study but was attached to the back of a mobile phone. The mobile payment application utilized the mobile phone’s camera to scan QR codes and automatically placed scanned items in a shopping cart. When participants pressed the ‘checkout’ button, the condition and the treatment conditions were performed with a Dunnett’s adjustment for multiple comparisons (one side, 5%). As predicted, participants in the lower-intensity vibration condition associated the payment with greater feelings of loss compared to participants in the control condition ($M_{\text{lower}} = 4.76$ ($SE = 0.34$), $M_{\text{control}} = 3.78$ ($SE = 0.31$); $t(57) = 2.14$, $p = .03$). By contrast, participants in the higher-intensity vibration condition did not associate the payment with significantly greater feelings of loss compared to participants in the control condition ($M_{\text{higher}} = 4.35$ ($SE = 0.31$), $M_{\text{control}} = 3.78$ ($SE = 0.31$); $t(57) = 1.30$, $p = .17$) (see Fig. 1). Notably, the focal contrast between participants in the lower-intensity and control conditions remained significant when gender and age were included as covariates in subsequent t-test comparisons with Dunnett’s adjustment ($p = .01$) (see Appendix D for additional detail on comparisons with covariates included). Finally, although not central to the predictions of this research, an additional analysis tested whether vibration intensity interacted with participants’ scores on the Need-for-Touch scale and found that it did not ($p = .54$).
application made the motor on the haptic feedback controller vibrate at either lower- or higher-intensities that were pre-set in the application.

4.1.2. Design and participants

One-hundred and sixty undergraduate participants (Mage = 22 years; female = 50%) from a public university were recruited for this study in exchange for a small monetary compensation and randomly assigned to a 2 (vibration intensity: higher vs. lower) × 2 (motor location: middle vs. edge) between-subjects experimental design. Importantly, to test the main hypothesis, another group of participants was assigned to a control condition, in which they received no vibration feedback when paying on the mobile application. Two participants who experienced a software glitch during the study were removed, leaving 158 participants. This resulted in a between-subjects design with 34 participants in the control condition, 30 participants in the lower-intensity/middle location condition, 29 participants in the lower-intensity/edge location condition, 33 participants in the higher-intensity/middle location condition, and 32 participants in the higher-intensity/edge location condition. The materials for this study were approved by the university’s Institutional Review Board and informed consent was gathered from all participants.

To maximize the external validity of this study, a 6’ high retail display shelf was set up that contained bags of chips from a variety of different brands (e.g., Lay’s, Ruffles, Cheetos, Tostitos). Each bag of chips in the display had a QR code beneath it, which participants used to scan the chips into the mobile application (see Appendix F). Although the chips were considerably lower priced than the computer desk in the pre-test ($4 per bag), prior work has found that consumers experience psychological loss even when purchasing small food items (e.g., Thomas, Desai, & Seenivasan, 2011; Soster, Gershoff, & Bearden, 2014). Further, chips were well suited for testing the mobile shopping app, as consumers often use such apps to store and purchase multiple items that they find while shopping.

Upon being recruited, participants first read a basic set of instructions outlining the steps of what they would be expected to do as part of the study. Next, participants were directed to a waiting area where an experimenter gave them further instructions on what to do. In particular, they were told that the researchers were developing and testing a mobile application and briefly shown the application. They were then told that there was a retail display in a room down the hallway containing several brands of chips. The experimenter instructed them to enter the room and shop around for three bags of chips that they would like to purchase. They were subsequently told to scan these chips into the shopping cart of the mobile application using the associated QR codes. The experimenter further informed participants that once they scanned the three bags of chips into the cart, they were to press the ‘Checkout’ button in the application and then wait for the ‘Payment Processing’ prompt to go away before coming out of the room. Prior to entering the room containing the retail display, the experimenter told participants to do their best to imagine that they were actually shopping and that the payment application was actually linked to their personal bank account.

Similar to the pre-test, participants were randomly assigned to receive different forms of haptic vibration feedback while they were viewing the ‘Payment Processing’ prompt running in the application. Specifically, participants were assigned to receive either lower- or higher-intensity feedback from a motor placed at either the back of the smartphone in the middle or placed on the lower left edge of the smartphone. Participants in the control condition did not receive any vibration feedback at all.

Upon exiting the room with the retail display, the experimenter asked participants to take a short survey. To better understand whether the vibration feedback induced participants to spend less, they responded to two separate measures. First, they indicated how much money they would be willing to spend (from $0 to $100 dollars) on their next trip to the grocery store using the same mobile payment application. Next, they rated their level of agreement as to whether the mobile payment application could help them monitor the amount of money they spend (1 = strongly agree; 7 = strongly disagree). Finally, participants responded to demographic questions of gender, age, and prior use of mobile payment applications.

4.2. Results

For both dependent measures (willingness-to-spend and monitoring spending), a 2 (vibration intensity) × 2 (motor location) ANOVA was run to determine whether there was an interactive effect of these two configuration variables. Then, to examine the main research question, the motor location conditions were collapsed (i.e., the conditions of participants who received vibration feedback from the middle and edge of the phone were merged together) if no differences between these groups were found. This allowed the analysis to better focus on the effects of the differing vibration intensities versus the control group. As in the pre-test, predictions were tested using two follow-up t-test comparisons of participants in the lower- and higher-intensity conditions to participants in the control condition. To correct for error rate for multiple comparisons between both treatment conditions and the control condition, Dunnett’s t-tests were performed (Hsu, 1996). It was predicted that participants in the lower-intensity condition would exhibit a significantly lower willingness-to-spend versus control, whereas participants in the higher-intensity condition would not exhibit a lower willingness-to-spend versus control.

4.2.1. Willingness-to-spend

One additional participant was missing data for the willingness-to-spend variable, so a total of 157 participants were used in this analysis. The initial 2 (vibration intensity) × 2 (motor location) ANOVA (excluding the control condition) did not reveal a significant interaction between the two configuration variables (F(1, 119) = 0.08, p = .77). However, it should be noted that participants who received the lower-intensity vibration feedback from a motor located in the middle of the phone reported the lowest mean willingness-to-spend using the application of any of the other conditions (see Fig. 2).

Due to the non-significant vibration intensity × motor location interaction, the motor location conditions were collapsed and a single factor ANOVA on the vibration intensity variable alone (control vs. lower-intensity vs. higher-intensity) was performed. This analysis revealed a non-significant main effect of vibration intensity (F(2, 154) = 1.89, p = .15). Similar to the pre-test, the directional main prediction was examined using t-test comparisons between the control condition and the treatment conditions with a Dunnett’s adjustment for multiple comparisons (one side, 5%). Consistent with expectations, participants in the lower vibration intensity condition were willing to spend significantly less money while shopping with the application versus participants in the control condition (Mlower = 41.37

Fig. 1. Mean perceptions of monetary loss associated with payment (1 = not at all; 7 = very much so) with standard error bars.
Fig. 2. Mean willingness-to-spend (in $) with standard error bars.

Fig. 3. Mean willingness-to-spend (in $) with standard error bars and motor location conditions collapsed.

Fig. 4. Mean ability to monitor spending with motor location conditions collapsed (1 = strongly disagree; 7 = strongly agree) with standard error bars.

5. General discussion

Across a pre-test and a main study, the present research finds evidence that pairing cashless payments with lower-intensity haptic vibration feedback can increase perceptions of loss or ‘pain’ associated with these payments and reduce consumers’ reported willingness-to-spend. In the pre-test, participants who received lower-intensity vibration feedback while imagining that they were making a purchase on an e-commerce website reported greater perceptions of monetary loss compared to a no-feedback control group. Consistent with this finding, participants in the main study reported a lower willingness-to-spend when they received lower-intensity vibration feedback while using a mobile payment application compared to a control group. These results suggest that lower-intensity vibration feedback may be effective at inducing consumers to spend less when paired with cashless payments.

The present research makes several contributions to the literature. First, although a large body of research has identified that cashless payment options can lead consumers to overspend (Prelec & Loewenstein, 1998; Prelec & Simester, 1998), almost no work has looked into how cashless payment can be modified to address this problem. The present research leverages work on multisensory design (e.g., Lee et al., 2009; Lee & Spence, 2008a, 2008b) to demonstrate that pairing lower-intensity vibration feedback with these payments is a practical solution, as the technology to control vibration intensity is included in the hardware of most mobile devices. Next, this research contributes to the emerging consumer literature that is looking at technology-mediated haptic feedback as a means of nudging consumers towards (or away from) certain actions (e.g., Hadi & Valenzuela, 2019). Up to this point, previous work has focused on encouraging consumers to engage in behaviors, such as exercise, that improve their health-related outcomes. By contrast, the present research explores haptic vibration feedback as a means of discouraging consumers from engaging in a behavior that can worsen their financial outcomes – overspending. Thus, this research adds to previous work on multisensory design as a means of providing feedback that can help to mitigate a negative outcome (Faust & Yoo, 2006; Ho et al., 2006; Jiang et al., 2005). Finally, by investigating the effects of different vibration intensities on consumer responses, this research contributes to a relatively new literature that looks at how differing configurations of vibration feedback can be used...
to elicit cognitive and affective responses (e.g., Abdullah et al., 2018; Yoo et al., 2015).

5.1. Limitations and future work

The authors acknowledge several limitations of this research. First, although we did our best to maximize the external validity of our studies, we were not able to completely immerse participants in a realistic retail environment where they were actually paying for the items they selected. In particular, given the difficulty of actually linking our applications to each participant’s personal bank account, participants in both studies were told to imagine that they were shopping and that the money being spent was their own. This is consistent with other work in HCI that has utilized imaginary scenarios (e.g., Brannon & Manshad, 2019). However, it is possible that participants did not “feel” the discomfort of paying as much as they would if the money was actually being withdrawn from their bank account. Notably, however, this limitation also speaks to the strength of our results—the effect of lower-intensity vibration feedback (vs. control) was significant even when participants were not actually spending money from their own account. Thus, it is likely that the effects we found are even stronger when participants spend their own money. That being said, future research might look at the effect of vibration feedback in a more realistic setting, where participants are actually spending their own money. For instance, researchers could attach a wearable that gives vibration feedback to customers at a coffee shop. They could then activate vibration feedback as consumers went to pay at the register. Afterwards, consumers could self-report their experience paying for their coffee.

Another limitation of the studies is that, in order to maintain external validity, they did not control for potential noise that participants could detect coming from the vibration motor (consumers can normally both hear and feel the motors on their devices). Thus, the possibility that participants responded to the noise of the motor rather than to the haptic vibration feedback cannot be entirely ruled out. Notably, in pretesting of the device, we did not believe the noise coming from the motor to be loud enough to be easily detected by participants, especially given the ambient noise in the lab. Further, we perceived the noise from the lower-intensity vibration setting to be virtually undetectable, even when there was no ambient sound. Because the lower-intensity vibration setting had the greatest effect on participants’ responses, we believe it is reasonable to conclude that it was the haptic vibration feedback, not audio feedback, that drove the effects in the studies. Even if participants did receive equal levels of haptic and audio feedback, some studies support the possibility that they would still be more sensitive to the haptic feedback (Chansey, Brill, Sitz, Schmuntzsch, & Bliss, 2014; Ng & Chan, 2012). Thus, future work may want to further explore the interaction between haptic and audio stimuli when they occur simultaneously in consumer contexts.

An additional limitation of this work is that we were only able to test a limited number of feedback configurations (i.e., two vibration intensities and two motor locations). We chose to limit the number of configurations in order to maximize the statistical power (i.e., the number of participants) of each condition. However, future work could examine the effectiveness of additional configurations of vibration intensity and motor location. Further, future work could incorporate additional configuration variables, such as the length of time that the vibration lasts. Perhaps future studies could also examine the effect of having multiple (vs. single) vibration motors on the phone. Indeed, prior studies have indicated that multi-touch haptic feedback is more noticeable than single-touch (Morioka & Griffin, 2005). Additionally, future research could further investigate other properties of the vibration feedback itself. It is possible that fade-in, fade-out, or pulsating effects could further enhance consumers’ awareness of making a payment.

A final limitation is that we cannot entirely discount alternative explanations for our results. For instance, one plausible alternative explanation for our findings in the main study is that participants in the lower-intensity vibration condition demonstrated a lower willingness-to-spend because the vibration feedback primed them to think about the unhealthiness of the food items (chips) they were shopping for. More specifically, if lower-intensity vibration feedback is associated with a negative emotional response, consumers may be more likely to react to negative cues in their shopping environment (not just payment). More research is needed to examine the effects of vibration intensity on how consumers perceive and react to stimuli in a shopping environment.

Because the current research explores the relative effect of vibration intensity (e.g., lower versus higher) on cashless payment, it did not seek to identify an absolute motor intensity threshold at which consumers would perceive the greatest sense of loss. We felt it was more important to initially establish the relative effect of vibration intensity because vibration motors are embedded in devices of different sizes, shapes, and material compositions, each of which absorbs vibration in different ways. Thus, the specific intensity setting of the motor in our studies does not necessarily represent an optimal intensity for manufacturers to create the effect on their own devices. Future work could investigate device-specific vibration thresholds at which consumers’ experience the greatest level of negative affect when exposed to different types of visual stimuli, such as the ‘processing payment’ prompt in the main study.

Future research could also investigate the role of crossmodal correspondence—or the tendency for people to associate a stimulus in one sensory modality with a stimulus in another sensory modality—in consumer responses to haptic feedback (Spence, 2011, 2012). In theorizing, we argued that one function of vibration feedback is to direct consumers’ visual attention towards the mobile device being used for payment. However, little is known about how vibration intensity might affect attention to different types of visual payment cues. For instance, given findings that people more readily associate lower pitch sounds with larger objects (e.g., Gallace & Spence, 2006; Marks, 2004), perhaps consumers receiving lower-intensity vibration feedback more readily attend to larger visual payment cues, such as a larger version of the ‘processing purchase’ visual prompt from the main study. Research looking at the effects of audio pitch on visual attention may also provide insights into the role of vibration feedback on cashless payment. For instance, studies have found that lower versus higher pitch sounds guide visual attention downwards (e.g., Klein & Juckes, 1989; Mossbridge, Grabowczyk, & Suzuki, 2011; Spence & Deroy, 2013). Perhaps an added benefit of lower vibration intensity feedback is that it guides consumers’ attention towards cashless payment methods that occur below their line of sight, such as when a phone scanner is located at counter-level.

5.2. Managerial implications

The most obvious implication of the findings of this research is for developers of any sort of cashless payment application (i.e. Apple Pay, Google Pay, Venmo, etc.). It is likely that using such applications instead of cash encourages consumers to overspend. Thus, application developers should strongly consider adding vibration feedback options that activate while payments are being processed. Our studies suggest that lower-intensity vibration feedback would be most effective at curbing overspending. One dilemma with this approach, however, is that many smartphone manufacturers hide APIs from application developers that allow them to control the device’s vibration intensity. Thus, a solution may require greater collaboration between software and hardware developers. Next, while we explored lower-intensity vibration as a means of discouraging a specific behavior, developers could explore using lower-intensity vibration feedback to discourage other negative behaviors as well. This insight is especially important because lower-intensity vibration appears to be able to convey negative information to consumers, while not being as annoying as higher-intensity vibration notifications. For instance, shopping apps could be
programmed to emit lower-intensity vibration when consumers add an unhealthy food item to their cart.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jbusres.2020.08.049.

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