Touching the Future: The Effects of Gesture-Based Interaction on Virtual Product Experience

Research-in-Progress

Yang Liu
National University of Singapore
15 Computing Drive, Singapore 117418
yangliu@comp.nus.edu.sg

Yi Shen
National University of Singapore
15 Computing Drive, Singapore 117418
shenyi@comp.nus.edu.sg

Hock Chuan Chan
National University of Singapore
15 Computing Drive, Singapore 117418
chanhc@comp.nus.edu.sg

Yan Lu
National University of Singapore
15 Computing Drive, Singapore 117418
isabellu@gmail.com

Deliang Wang
Institute of High Performance Computing, Agency for Science, Technology and Research (A*STAR), Singapore
1 Fusionopolis Way, #16-16 Connexis, Singapore 138632
wangdl@ihpc.a-star.edu.sg

Abstract

With the popularity of touchscreen tablets and gesture control devices, the role of touch in online consumer behavior has become increasingly important. This study aims to investigate how sense of touch evoked by various interaction modes (i.e., mouse-driven interaction, touchscreen gesture interaction and mid-air gesture interaction) influences virtual product experience. Drawing on Feelings-as-Information Theory and Cognitive-Affective Framework in virtual product experience, we propose that sense of touch could influence consumer purchase intention by reducing product uncertainty and improving product attachment; furthermore, these effects are contingent on product characteristics, i.e., importance of product haptics and product valence. Accordingly, two lab experiments are designed. Potential theoretical contributions, practical implications as well as future research directions are discussed.

Keywords: Gesture-based interaction, virtual product experience, sense of touch, feelings-as-information

Introduction

Online shopping and product information seeking have become an indivisible part of modern life. People explore products via various digital devices, e.g., desktops, laptops, tablets, smartphones, and even virtual reality devices. Although mouse is still the dominant tool in product interaction, it is giving way to touchscreens and kinetic controllers (Brasel and Gips 2014; Steinmann et al. 2014). When using mouse, consumers interact with products by clicking, scrolling and dragging the mouse. In contrast, new devices allow online consumers to interact with products directly with gestures. For example, a consumer could tap, drag and stretch a product on the touchscreen, which is termed as *touchscreen-based gesture interaction*. With kinetic and gesture recognition tools such as Leap Motion and Kinect, people could reach, point and manipulate a product with finger, hand and body movements in the air, which is termed as *mid-air gesture interaction* (Saffer 2008). The emerging gesture-based interaction is changing consumer's virtual product experience, i.e., the way consumers feel, touch and try products via web interfaces (Jiang and Benbasat 2007a); however, the effects of such changes are unclear.

One major difference among the above-mentioned human-device interaction modes (i.e., mouse, touchscreen gesture, and mid-air gesture) is that they might elicit different senses of touch, i.e. the extent to which users feel they can touch the product during the interaction. Feelings-as-Information theory and sensory marketing literature suggest that consumer judgment is the result of multiple sensory channels, i.e., vision, audition, haptics, smell and taste (Krishna 2012; Krishna and Schwarz 2013; Schwarz 2011). In particular, touch (i.e., haptics) could influence consumer behavior by providing product-related information and invoking hedonic sensory experiences (Klatzky and Peck 2012). Although touch has been described as the most fundamental means of contact with the world (Barnett 1972) and the simplest and most straightforward channel of all sensory systems (Geldard 1960), virtual touch on products has been understudied in the mouse-dominant era. Recently, a study shows that sense of touch could be influenced by mediated device, i.e., touchscreen on tablet and touchpads on laptop could elicit different degrees of touch, which further influences perceived product ownership and endowment (Brasel and Gips 2014). It suggests that although people could not physically touch the products, the mediated touch could to some extent act as real tactile input and further influence consumer judgment and behavior. Yet, it remains unexplored whether mouse-mediated touch, touchscreen-mediated touch, and mid-air-mediated touch contain different sensorimotor information and elicit different perceptions of virtual product experience.

Virtual product experience has been a well-established research domain in information systems. Generally, consumers want to access information that might be necessary for evaluating products to make informed product choices. However, the interface constrains product understanding and evaluating. Therefore, research on virtual product experience has been focusing on how different product presentation formats influence product understanding, mental imagery and cognitive elaboration (e.g., Jiang and Benbasat 2007a; Schlosser 2003). Besides the cognitive effects, virtual product experience could also influence consumer judgment and purchase in a more affective way. For example, prior literature indicates that a more entertaining and enjoyable experience is believed to increase product evaluation and lead to more favorable attitudes towards the website (e.g., Park et al. 2005). In fact, several studies adopted the cognitive-affective framework to understand virtual product experience (e.g., Jiang and Benbasat 2007b; Nah et al. 2011; Xu et al. 2014). However, these studies are in the mouse-based interaction context, in which only visual and auditory modalities are emphasized. With the prevalence of touchscreens, touchpads and gesture controllers, which enrich consumer's touching experience, we believe that investigating the cognitive and affective effects of touch could broaden our understanding of virtual product experience in the new era.

Therefore, this study aims to investigate two research questions: i) How different interaction modes (mouse-based interaction, touchscreen gesture interaction and mid-air gesture interaction) influence sense of touch and ii) How sense of touch influences virtual product experience cognitively and affectively. To be specific, we predict that touch-screen gesture interaction will lead to a higher sense of touch over mid-air gesture and mouse-based interaction. Sense of touch further influences how people react to products through a cognitive mechanism (product uncertainty) as well as through an affective mechanism (product attachment). We also investigate the boundary conditions of such effects, i.e., how the effects of sense of touch on product uncertainty and product attachment are contingent on product types.

Literature Review

Feelings-as-Information Theory

Unlike traditional information processing theories, which highlight that human mind and cognition determine feelings, judgment and actions (Lachman et al. 1979), feelings-as-information theory (Schwarz 2011) stresses the important role which subjective feelings play in human cognition. In particular, the subjective feelings include moods, emotions, metacognitive experiences, as well as bodily sensations. Based on two streams of literature, i.e., affect-as-information and embodied cognition, feelings-as-information theory provides a holistic framework to understand how feelings influence judgment and behavior. Affect is conceived of as an umbrella term for a set of concepts that includes emotions, moods, and feelings (Bagozzi et al. 1999; Liljander and Mattsson 2002; Russell 2003). Empirical studies in organizational behavior, marketing, social psychology and management have confirmed that affect is a strong determinant of job satisfaction (Weiss et al. 1999), decision making (Mittal and Ross 1998), consumer purchase (Childers et al. 2001), attitude change and persuasion (Petty et al. 2001). In information systems literature, researchers are increasingly examining the affective dimensions in human-computer interaction (for reviews, see Sun and Zhang 2006; Zhang 2013). In addition to affect, feelings-as-information theory also highlights that bodily experiences shape our thoughts by providing information that parallels the implications of affective and cognitive feelings, which has been widely examined in embodied cognition literature (Barsalou 2008; Meier et al. 2012; Niedenthal et al. 2005). It's proposed that our bodily feelings can serve as informational input to consumer judgment, regardless of whether the bodily feelings are an integral part of the judgment task or arise from incidental factors that are irrelevant to the judgment task.

Based on feelings-as-information theory, there has been a surge of interest in investigating the role of bodily sensory experience in judgment and decision making. Recently, a series of empirical findings demonstrate that consumer judgment is the outcome of multiple senses, i.e., vision, audition, haptics, smell and taste (Krishna 2012). Among the five senses, haptics (i.e., touch) is a recent area of inquiry in consumer behavior research, which mainly focused on two streams, i.e., products touching each other and human touching products (Jansson-Boyd 2011; Peck and Childers 2003). For example, according to product contagion theory, offensive properties of disgusting products (e.g., feminine napkins, diapers, trash bags) are believed to transfer to other products through physical contact. This transfer of properties influences subsequent consumer responses and evaluations (Morales and Fitzsimons 2007). In terms of human touching products, prior literature indicates that touching a product can increase consumer confidence in the evaluation process as it provides additional information; therefore, tactile input remarkably improves evaluation of products with characteristics that are best explored by touch (e.g., softness and texture for the evaluation of a pillowcase) (Peck and Childers 2003; Spence and Gallace 2011). It is important to note that even when haptic information is not diagnostic, touch could still improve consumer attitudes towards the focal product, as touch induces perceived ownership and endowment effect (Peck and Shu 2009). Moreover, touch could also elicit positive affective response particularly when the touch provides neutral or positive sensory feedback (Peck and Wiggins 2006).

Feelings-as-information theory has important implications for human-computer interaction research. First, it highlights the importance of bodily sensations (e.g., sense of touch) in understanding consumer judgment and behavior. Second, it indicates that affective responses to stimuli are as important as cognitive responses. Drawing on feelings-as-information theory, our study aims to examine an important but understudied modality, i.e., haptics, in virtual product experience and its cognitive and affective effects.

Gesture-Based Interaction

With the prevalence of touchscreen devices and the emergence of kinetic controllers, gesture is playing an important role in human-computer interaction. Saffer (2008) classifies gesture-based interaction into two categories, i.e., touchscreen interaction and mid-air interaction. Touchscreen interaction requires the user to directly touch the screen of a device or surface, whereas mid-air interaction allows freeform gestures without being in contact with any surface. Several advantages of gesture-based input have been identified, including naturalness and expressiveness, learnability, freedom, and the ability to leverage existing dexterous skills. Yet, gesture-based interaction technologies are also challenged by inaccurate recognition

as well as physical discomfort and fatigue caused by prolonged use of gestures (van Beurden et al. 2012). Prior literature on gesture-based interaction is usually from the technical perspectives but studies on the physiological and psychological effects of gesture-based interaction are scarce (Maher et al. 2014).

Gesture-based interaction could influence haptic perceptions in the context of virtual product experience. For example, Brasel and Gips (2014) found that compared with iPad touchscreen, mouse or touchpad (on laptop) leads to a lower degree of touch, and consequently a lower level of consumer endowment. Similarly, Steinmann et al. (2014) found that compared with mouse, touchscreen could elicit more vivid mental imagery of using the product. However, these studies mainly focused on touchscreen gesture interaction and it is still unknown whether mid-air gesture interaction would differ from touchscreen gesture interaction in terms of eliciting sense of touch. Although touchscreen and mid-air gesture interactions share some common characteristics, they also differ in several aspects. For instance, mid-air gesture recognition devices (e.g., Leap Motion and Kinect) can capture hand postures and motions in 3D-space and decouple the hand from a touch-sensing surface thereby allowing for an increase in gesture complexity and functionality (Rempel et al. 2014). When people interact with products using touchscreen gestures, they could touch the tangible interface and explore the products with pinching, flicking and swiping (Radhakrishnan et al. 2013). However, when people interact with products with mid-air gestures, they move fingers in the air to control the products by pointing, stabbing and rotating without direct contacting with any tangible interface. In this study, we aim to investigate whether and how different types of interaction influence virtual product experience by eliciting different sense of touch.

Virtual Product Experience

Consumers can experience products in three ways: directly (with physical or actual trials), indirectly (with third-party information such as advertising and reviews) and virtually (with virtual representations of the products). In prior literature, virtual product experience has been defined as the process that consumers interact and learn about products in a mediated environment through visual and auditory modalities (Suh and Lee 2005). As touchscreen and kinetic devices are increasingly prevalent, they are becoming the primary means in which consumers virtually explore and experience the products. Thus, we believe that taking touch into consideration could further enrich knowledge about virtual product experience.

Prior virtual product experience literature highlights that cognition and affect simultaneously influence consumer attitudes towards the product and the website (Xu et al. 2014). From a cognitive perspective, virtual product experience could influence consumer product understanding, which further influences purchase intention. For example, interactivity and vividness induced by different product presentation formats could influence consumer actual product knowledge and perceived website diagnosticity (Jiang and Benbasat 2007a; Schlosser 2003). Suh and Lee (2005) found that virtual reality enabled consumers to learn about products by providing high-quality 3D images, higher interactivity and increased telepresence. Along with this stream of literature, many features have been found to impact product understanding, cognitive elaboration and mental imagery, such as image quality (Jeong et al. 2009; Park et al. 2005), visual and functional control (Jiang and Benbasat 2004; Jiang and Benbasat 2007b; Schlosser 2003), 3D presentation (Nah et al. 2011; Steinmann et al. 2014) and virtual mirror applications (Verhagen et al. 2014). Although virtual product experience could enable consumers to "feel, touch and trial", product uncertainty caused by partial and incomplete information (e.g., lack of physical contact) is still an impediment to online markets (Dimoka et al. 2012; Hong and Pavlou 2014). Improving consumer trust and reducing product uncertainty have drawn interest from both researchers and practitioners (Bock et al. 2012). As prior studies on human product contact indicate that touch could improve consumer trust and confidence (Peck 2010), in this study, we are particularly interested in whether virtual touch induced by different interaction modes could influence perception of product uncertainty.

Virtual product experience could also influence consumer purchase behavior by eliciting affective reactions. For example, prior literature suggests that product presentation formats could affect shopping enjoyment (Jiang and Benbasat 2007b), affective involvement (Jiang et al. 2010), and mood (Park et al. 2005), which further influence consumer attitudes towards the website. At the product level, virtual product experience could increase purchase intention by improving engagement (Yi and Jiang 2015), product likability (Verhagen et al. 2014) and perceived ownership (Brasel and Gips 2014). To represent users' affective reactions, we propose the construct of *product attachment*, which is defined as an emotional bond a consumer experiences with a product (Mugge et al. 2006). Attachment is developed

from interaction, which could be influenced by bodily experience, such as gestures and touch (Hadi and Valenzuela 2014; Peck and Shu 2009). Attachment theory suggests that the establishment of an emotional bond with an object predicts an individual's approach behavior towards it (Ball and Tasaki 1992; Thomson et al. 2005). In summary, the product uncertainty and product attachment constructs that represent users' cognitive and affective dimensions of virtual product experience are important factors to predict purchase behavior and are highly relevant considering the nature of touch.

Research Model and Hypothesis Development

Drawing on Feelings-as-Information Theory and Cognitive-Affective Framework in virtual product experience, our study aims to examine how sense of touch elicited by interaction mode (i.e., mid-air gesture vs. touchscreen gesture vs. mouse) influences the cognitive (i.e., product uncertainty) and affective (i.e., product attachment) dimensions of virtual product experience and thus determines consumer purchase intention. The theoretical model is presented in Figure 1.

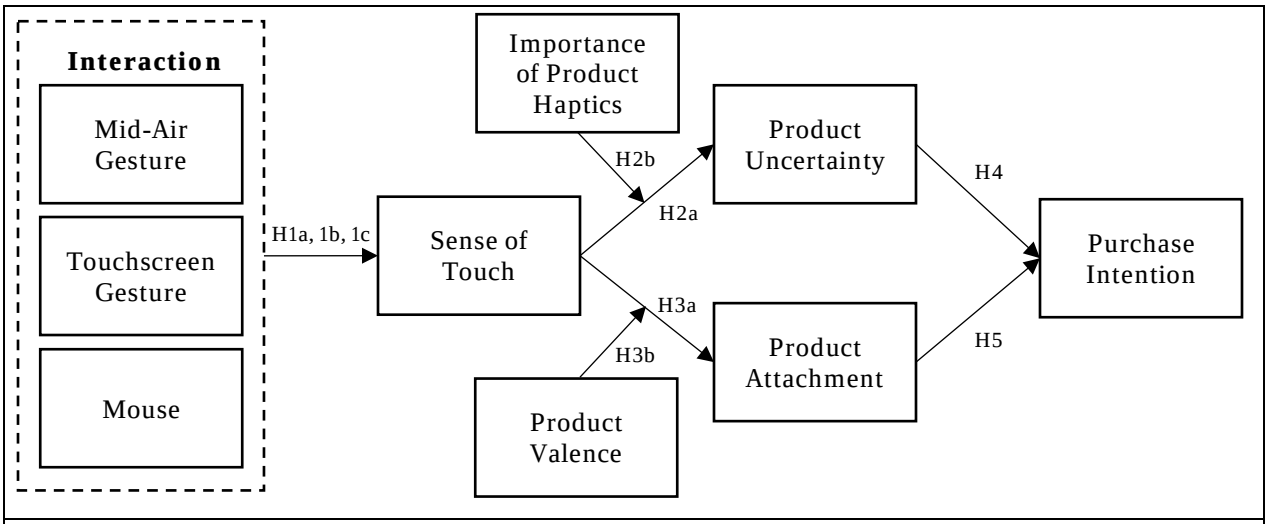

Figure 1. Research Model

Effects of Interaction Modes on Sense of Touch

Prior literature indicates that gesture is an intuitive and natural way in human-computer interaction (van Beurden et al. 2012). When using mid-air gestures, consumers could move hands and fingers just like they are touching an intangible product in the air, which could give them a more natural and vivid simulation of touch. Similarly, on touchscreens, consumers could directly manipulate the products and the products would respond to their touch gestures (Shen et al. 2006). In contrast, when using a mouse, consumers can only experience products through clicking and dragging the mouse and have to mentally translate the mouse movements into touch experience. Although touch is defined as "sensations aroused through the stimulation of receptors in the skin" (Stevens and Green 1996, p. 1), previous research has shown that vivid haptic imagery, or imagining touching an object, can have the same effect as physical touch (Peck et al. 2013). As mid-air gestures and touchscreen gestures could elicit more vivid haptic imagery than mouse, we hypothesize that:

H1a: Compared with mouse, mid-air gesture interaction leads to a higher sense of touch.

H1b: Compared with mouse, touchscreen gesture interaction leads to a higher sense of touch.

Although gesture-based interaction in general can bring more naturalness and more real experience than mouse-driven interaction, it is still unknown how mid-air and touchscreen gestures differ in generating sense of touch. Prior research suggests that although haptic imagery could to some extent act as real tactile input, touch, known as near sense or proximal sense, still requires direct contact on the skin (Peck 2010). When moving fingers in the air, there is a distance between consumers and products. In contrast, moving fingers on a tangible touchscreen, consumers directly "touch" the products on the interface, which might elicit a more real sense of touch. Therefore, we propose that:

H1c: Compared with mid-air gesture interaction, touchscreen gesture interaction leads to a higher sense of touch.

Cognitive and Affective Consequences of Sense of Touch

The intangible nature of online shopping makes consumers suffer from product uncertainty. Unlike consumers in the offline markets, buyers in online markets can only experience products via the interface by reading descriptions and customer reviews, as well as virtually interacting with product images or videos. In prior literature, vision and audition are the two modalities that are considered in virtual product experience (Suh and Lee 2005). However, consumer judgment and decision making is the outcome of multisensory information processing and different sensory modalities receive distinct types of information in consumer–product interaction. In particular, touch is essential in the evaluation of product's substance properties such as hardness and texture, which could not be obtained through visual inspection (Klatzky et al. 1991). In addition, the impact of touch still exists even when people do not have direct contact but simply imagine touching the product (Peck et al. 2013). Therefore, even though the touching experience is not real when consumers are interacting with devices, the simulated touch movement may still reduce consumer uncertainty by eliciting more vivid mental imagery. As feelings-as-information theory posits, bodily states could influence cognitive processing, and the action of touch could facilitate haptic mental imagery (Peck and Childers 2003; Schwarz 2011). Hence, when people are feeling that the virtual touch is more close to real touch, they will form more vivid imagery and experience higher sense of presence, thus perceiving less product uncertainty caused by the intangibility nature of online shopping (Laroche et al. 2005). Therefore, we expect that:

H2a: Increased sense of touch reduces product uncertainty.

Though we hypothesize that virtual touch could reduce perceived product uncertainty by boosting mental imagery and sense of presence, such effects might be contingent on product category. Prior literature reveals that the relative importance of haptics varies across product categories (Grohmann et al. 2007). Tactile input is of particular importance in the evaluation of products of which substance properties are predictive of their performance, such as fashion clothes and toys (Lederman and Klatzky 1993). More recent study revealed that even allowing consumers to touch some irrelevant objects could increase their confidence in product evaluations (Peck 2010). When consumers are evaluating products such as fashion clothes and toys without direct touch, they may feel some important information is missing. Therefore, the action of touch, which facilitates haptic imagery, could reduce product uncertainty notably. However, for products that do not need haptic information for evaluation, sense of touch might not have much impact reducing product uncertainty. Hence, we predict that:

H2b: Importance of product haptics moderates the effect of sense of touch on product uncertainty, i.e., for products requiring haptic information in judgment, the effect of sense of touch on product uncertainty will be stronger.

In addition, sense of touch could also influence the affective dimensions of virtual product experience in terms of product attachment. Attachment is established through interaction thus can be influenced by consumer's bodily interaction with the product. For example, Hadi and Valenzuela (2014) found that affectionate gestures (e.g., hug) is more likely to induce emotional attachment than general gestures (e.g., approach). Similarly, consumers could interact with products via touch. From ancient times, touch has been seen as synonymous with affection and warmth (Montagu 1971). Thus, a more realistic touch could help consumers establish affection, love and emotional connection with the product. For example, Peck and Shu (2009) found that mere touch or imagining touch could improve one's perceived ownership of the products, which further leads to an endowment effect. Moreover, touch can be considered a form of approach behavior, which can induce liking and preference (Hornik 1992). Hence, it is conceivable to expect that higher sense of touch will lead to higher product attachment. Therefore, we propose that:

H3a: Increased sense of touch enhances product attachment.

To validate our hypothesized association between sense of touch and product uncertainty, we examine the interaction effect of sense of touch and product valence on attachment. Specifically, we expect that the effect of sense of touch on product attachment would be less salient when browsing disgusting (vs. desirable) products. According to product contagion theory, offensive properties of disgusting products (e.g., feminine napkin, oil, and cigarettes) are believed to transfer to other products through physical

contact. Morales and Fitzsimons (2007) found that a disgusting product may lower consumers' evaluation of the other product that is physically contiguous to it. Similarly, when people are touching a disgusting product, they may feel that the disgusting product is contaminating their hands, making the touching experience negative. As attachment arises from the association developed through the interaction and consumption experience (Kleine et al. 1995), when consumers are exposed to disgusting products, the positive effect of touch on attachment might be mitigated by the negative feelings. Therefore, we hypothesize that:

H3b: Product valence moderates the effect of sense of touch on product attachment, i.e., for disgusting products, the effect of sense of touch on product attachment will be weaker.

Overall Effects on Purchase Intention

Prior literature in marketing and information systems suggests that consumer purchase intention is influenced by both cognitive and affective factors (e.g., Jiang and Benbasat 2007b; Park et al. 2005; Van der Heijden et al. 2003). In line with these studies, we investigate how product uncertainty and product attachment influence purchase intention. Product uncertainty is defined as "the buyer's difficulty in assessing the product's characteristics and predicting how the product will perform in the future" (Dimoka et al. 2012, p. 397), which has been demonstrated to have a negative effect on consumer decisions, such as inducing regret and return (Hong and Pavlou 2014; Tsiros and Mittal 2000). It also raises risk perceptions, which has been recognized as an obstacle in purchase due to the intangible nature of online shopping (Gefen et al. 2008; Park et al. 2005). Therefore, we predict that:

H4: Increased product uncertainty reduces purchase intention.

Affective responses have been recognized as powerful drivers in consumer decision making (Cohen et al. 2008; Schwarz 2011). As attachment related literature suggests, the establishment of an emotional bond with an object predicts the nature of an individual's behavior towards it (Ball and Tasaki 1992). For example, Thomson et al. (2005) found that attachment could predict consumers' willingness to make monetary sacrifices in order to obtain and keep objects. Similarly, Miller (1997) found that individuals who are strongly attached to a person or object are generally committed to preserving their relationship with it. Thus, it is conceivable that when people establish a tight bond and attachment with a certain product during the interaction process, they will be more willingly to own it to keep their bond. Thus, we hypothesize that:

H5: Increased product attachment enhances purchase intention.

Research Methodology

To test the hypotheses, two 3 (interaction mode: mid-air gesture vs. touchscreen gesture vs. mouse) by 2 (product category) between-subjects lab experiments will be conducted. In experiment 1, we will focus on how sense of touch elicited by different interaction modes influences consumer virtual product experience in situations where the importance of haptic information differs. Importance of product haptics will be manipulated by creating product assortments for sweatshirts in the high-haptic condition, and Bali walking tours in the low-haptic condition, which has been demonstrated to be effective in prior literature (Brasel and Gips 2014). In experiment 2, we will investigate how the influence of sense of touch on consumer experience differs for nice products vs. disgusting products. Toys would be used as our stimuli. Half of the participants would be asked to choose among five cute cartoon toys, such as cats and bears (nice condition), while the other half would be required to choose among five Halloween toys, such as snakes and cockroaches (disgusting condition). Before the experiment, we will conduct a pretest to demonstrate the products are appropriate.

A simulated e-commerce website has been developed. On the website, participants could interact with 5 product options using mouse, touchscreen or mid-air gesture control device. Four typical types of information will be presented, including product image, short description, price, and specifications. Users could click on an image on the home page to view product page, on which they could scroll up and down to browse product descriptions. The product page provides four thumbnail images showing the focal product from different perspectives. Participants could hover on each thumbnail image to view detailed locality of the product. In the mid-air gesture condition, they will interact with the website via Leap Motion, which is a device that facilitates user interaction with computers via mid-air gestures. Leap

Motion controller can create a virtual "touch" surface in the air, and recognize participants' gestures when they move hands over the device (as shown in Figure 2 in Appendix). Participants can interact with the products by stabbing (a simulation of click), pointing and moving (a simulation of hover) their index finger. They could scroll the product page by moving their hands up and down. In the touchscreen condition, participants could tap on thumbnail images, and move their fingers on the image to see the partial details. The third group will interact using a mouse. During the experiment, the subjects will be first guided on how to interact with the website. In the mid-air gesture condition, an interactive tutorial will be provided so that they could try out and get familiar with the device. The tutorial will teach the participants how to click, hover, and scroll with Leap Motion. Then the participants will be introduced to the task, i.e., making a purchase decision among five alternatives by interacting with the products and going through the product information. After completing the task, they will be asked to answer a post-experimental questionnaire which captures our major constructs. Product Valence (Elder and Krishna 2012) and Importance of Product Haptics (Brasel and Gips 2014) will be measured as manipulation checks. Measurement items for sense of touch will be adapted from Brasel and Gips (2014) and Nepomuceno et al. (2012). Product uncertainty and product attachment will be measured with items adapted from Dimoka et al. (2012) and Thomson et al. (2005), respectively. We will also measure ease of use, demographic information and individual factors (e.g., need for touch) as control variables.

Conclusion

Gesture-based interaction is becoming increasingly prevalent in this digital world. It challenges how we understand virtual product experience as it changes the way we sense and manipulate products. This study contributes to the literature in several ways. First, it enriches the literature on virtual product interaction by investigating how gesture-based interactions (compared with mouse) influence consumer judgment and attitudes. In particular, we suggest that different interaction modes could elicit different level of touch, and thereby influence product uncertainty, product attachment and purchase intention. Secondly, it calls for the incorporation of physical feelings into virtual product experience research. When people interact with touchscreen, kinetic and wearable devices, they could get richer sensory and physical experience than when they interact with computers using mouse and keyboard. As physical feelings influence human judgment and behavior and they can be manipulated by ICT (Harvie et al. 2015), understanding the relationship between physical experience and ICT would be important for future HCI research. As most research on touch focuses on touch-imagery, interpersonal touch, or contiguous products (Brasel and Gips 2014; Krishna 2012), our study also contributes to the field of sensory marketing. By adopting the cognitive-affective framework, we provide a holistic model to understand how haptic sensory could be elicited by human-computer interaction and how it would influence product evaluation. The experiments could, potentially, show that as a sensory input, sense of touch could reduce product uncertainty and improve product attachment. The experiments are expected to show that these effects are contingent on product characteristics, i.e., importance of product haptic and product valence.

The present study also has potential implications for online retailing practice. First, our study could demonstrate the advantage of gesture-based interaction in eliciting virtual product experience. Practitioners, especially those selling products requiring haptic information, should invest in mobile channels to improve sense of touch. However, practitioners selling products that might elicit disgusting or negative feelings should be cautious when designing for mobile and virtual reality experience. Probably they need to adopt designs that could reduce sense of touch or provide less vivid images. Moreover, as mobile, virtual reality and augmented reality technologies, which allow for more interactive product presentation, are becoming mature, practitioners need to take sensory and physical experience into consideration when designing for virtual product experience.

As the focus of this study is to compare the effects of different interaction modes, we keep product presentation format constant among the three conditions. Due to the ease-of-use concerns, currently we only investigate simple mid-air gestures that can be used to explore products. Prior literature indicates that different gestures might have different metaphorical meanings, which might lead to different learnability, cognitive and affective reactions. In future studies, we plan to design more lab experiments with different types of product presentation, such as 3D display vs. 2D display, and investigate sensory feedbacks that might be elicited by more complex gestures.

Acknowledgement

The work was supported by Singapore MOE's AcRF Tier 1 grant, T1 251RES1311. In addition, the authors would like to thank the editor and reviewers for expert comments and helpful advices.

Appendix

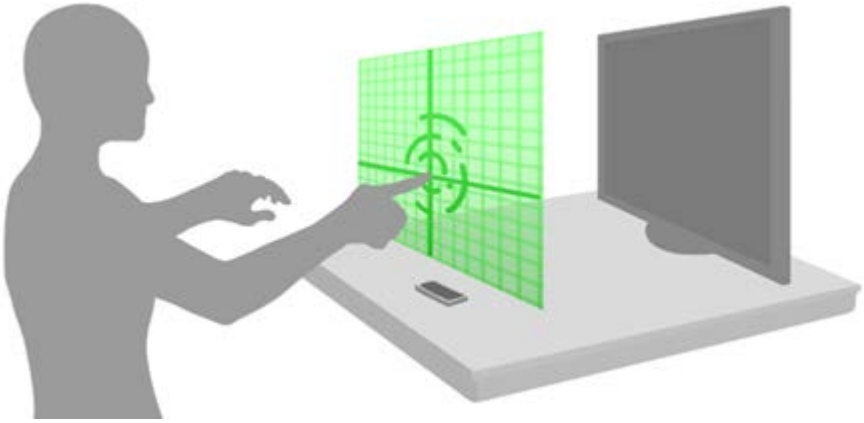

Figure 2. Virtual "Touch" Surface Created by Leap Motion Controller

Note. The Leap Motion Controller consists of two cameras and three infrared LEDs, giving a virtual interaction 3D space. In this experiment, the device would be used to create a virtual "touch" surface in the area. Adapted from "Touchless Reference Guide". Copyright 2015 by Leap Motion, Inc.

References

Bagozzi, R.P., Gopinath, M., and Nyer, P.U. 1999. "The Role of Emotions in Marketing," *Journal of the Academy of Marketing Science* (27:2), pp. 184-206.

Ball, A.D., and Tasaki, L.H. 1992. "The Role and Measurement of Attachment in Consumer Behavior," *Journal of Consumer Psychology* (1:2), pp. 155-172.

Barnett, K. 1972. "A Theoretical Construct of the Concepts of Touch as They Relate to Nursing," *Nursing Research* (21:2), pp. 102-109.

Barsalou, L.W. 2008. "Grounded Cognition," *Annual Review of Psychology* (59), pp. 617-645.

Bock, G.-W., Lee, J., Kuan, H.-H., and Kim, J.-H. 2012. "The Progression of Online Trust in the Multi-Channel Retailer Context and the Role of Product Uncertainty," *Decision Support Systems* (53:1), pp. 97-107.

Brasel, S.A., and Gips, J. 2014. "Tablets, Touchscreens, and Touchpads: How Varying Touch Interfaces Trigger Psychological Ownership and Endowment," *Journal of Consumer Psychology* (24:2), pp. 226-233.

Childers, T.L., Carr, C.L., Peck, J., and Carson, S. 2001. "Hedonic and Utilitarian Motivations for Online Retail Shopping Behavior," *Journal of Retailing* (77:4), pp. 511-535.

Cohen, J.B., Pham, M.T., and Andrade, E.B. 2008. "The Nature and Role of Affect in Consumer Behavior," in *Handbook of Consumer Psychology*, C.P. Haugtvedt, P.M. Herr and F.R. Kardes (eds.). New York: Lawrence Erlbaum Associates, pp. 297-348.

Dimoka, A., Hong, Y., and Pavlou, P.A. 2012. "On Product Uncertainty in Online Markets: Theory and Evidence," *MIS Quarterly* (36:2), pp. 395-426.

Elder, R.S., and Krishna, A. 2012. "The "Visual Depiction Effect" in Advertising: Facilitating Embodied Mental Simulation through Product Orientation," *Journal of Consumer Research* (38:6), pp. 988-1003.

Gefen, D., Benbasat, I., and Pavlou, P. 2008. "A Research Agenda for Trust in Online Environments," *Journal of Management Information Systems* (24:4), pp. 275-286.

Geldard, F.A. 1960. "Some Neglected Possibilities of Communication," *Science* (131), pp. 1583-1588.

Grohmann, B., Spangenberg, E.R., and Sprott, D.E. 2007. "The Influence of Tactile Input on the Evaluation of Retail Product Offerings," *Journal of Retailing* (83:2), pp. 237-245.

Hadi, R., and Valenzuela, A. 2014. "A Meaningful Embrace: Contingent Effects of Embodied Cues of Affection," *Journal of Consumer Psychology* (24:4), pp. 520-532.

Harvie, D.S., Broecker, M., Smith, R.T., Meulders, A., Madden, V.J., and Moseley, G.L. 2015. "Bogus Visual Feedback Alters Onset of Movement-Evoked Pain in People with Neck Pain," *Psychological Science* (26:4), pp. 385-392.

Hong, Y., and Pavlou, P.A. 2014. "Product Fit Uncertainty in Online Markets: Nature, Effects, and Antecedents," *Information Systems Research* (25:2), pp. 328-344.

Hornik, J. 1992. "Tactile Stimulation and Consumer Response," *Journal of Consumer Research* (19:3), pp. 449-458.

Jansson-Boyd, C.V. 2011. "The Role of Touch in Marketing: An Introduction to the Special Issue," *Psychology & Marketing* (28:3), pp. 219-221.

Jeong, S.W., Fiore, A.M., Niehm, L.S., and Lorenz, F.O. 2009. "The Role of Experiential Value in Online Shopping: The Impacts of Product Presentation on Consumer Responses Towards an Apparel Web Site," *Internet Research* (19:1), pp. 105-124.

Jiang, Z., and Benbasat, I. 2004. "Virtual Product Experience: Effects of Visual and Functional Control of Products on Perceived Diagnosticity and Flow in Electronic Shopping," *Journal of Management Information Systems* (21:3), pp. 111-147.

Jiang, Z., and Benbasat, I. 2007a. "The Effects of Presentation Formats and Task Complexity on Online Consumers' Product Understanding," *MIS Quarterly* (31:3), pp. 475-500.

Jiang, Z., and Benbasat, I. 2007b. "Investigating the Influence of the Functional Mechanisms of Online Product Presentations," *Information Systems Research* (18:4), pp. 454-470.

Jiang, Z., Chan, J., Tan, B.C., and Chua, W.S. 2010. "Effects of Interactivity on Website Involvement and Purchase Intention," *Journal of the Association for Information Systems* (11:1), pp. 34-59.

Klatzky, R.L., Lederman, S.J., and Matula, D.E. 1991. "Imagined Haptic Exploration in Judgments of Object Properties," *Journal of Experimental Psychology: Learning, Memory, and Cognition* (17:2), pp. 314-322.

Klatzky, R.L., and Peck, J. 2012. "Please Touch: Object Properties That Invite Touch," *IEEE Transactions on Haptics* (5:2), pp. 139-147.

Kleine, S.S., Kleine III, R.E., and Allen, C.T. 1995. "How Is a Possession" Me" or" Not Me"? Characterizing Types and an Antecedent of Material Possession Attachment," *Journal of Consumer Research* (22:3), pp. 327-343.

Krishna, A. 2012. "An Integrative Review of Sensory Marketing: Engaging the Senses to Affect Perception, Judgment and Behavior," *Journal of Consumer Psychology* (22:3), pp. 332-351.

Krishna, A., and Schwarz, N. 2013. "Sensory Marketing, Embodiment, and Grounded Cognition: A Review and Introduction," *Journal of Consumer Psychology* (24:3), pp. 159-168.

Lachman, R., Lachman, J.L., and Butterfield, E.C. 1979. *Cognitive Psychology and Information Processing: An Introduction*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Laroche, M., Yang, Z., McDougall, G.H., and Bergeron, J. 2005. "Internet Versus Bricks-and-Mortar Retailers: An Investigation into Intangibility and Its Consequences," *Journal of Retailing* (81:4), pp. 251-267.

Lederman, S.J., and Klatzky, R.L. 1993. "Extracting Object Properties through Haptic Exploration," *Acta Psychologica* (84:1), pp. 29-40.

Liljander, V., and Mattsson, J. 2002. "Impact of Customer Preconsumption Mood on the Evaluation of Employee Behavior in Service Encounters," *Psychology & Marketing* (19:10), pp. 837-860.

Maher, M.L., Clausner, T., Tversky, B., Kirsh, D., Kay, J., Danielescu, A., and Grace, K. 2014. "Gesture-Based Interaction Design: Communication and Cognition," *CHI'14 Extended Abstracts on Human Factors in Computing Systems*: ACM, pp. 61-64.

Meier, B.P., Schnall, S., Schwarz, N., and Bargh, J.A. 2012. "Embodiment in Social Psychology," *Topics in Cognitive Science* (4:4), pp. 705-716.

Miller, R.S. 1997. "Inattentive and Contented: Relationship Commitment and Attention to Alternatives," *Journal of Personality and Social Psychology* (73:4), p. 758.

Mittal, V., and Ross, W.T. 1998. "The Impact of Positive and Negative Affect and Issue Framing on Issue Interpretation and Risk Taking," *Organizational Behavior and Human Decision Processes* (76:3), pp. 298-324.

Montagu, A. 1971. *Touching: The Human Significance of the Skin*. New York: Columbia University Press.

Morales, A.C., and Fitzsimons, G.J. 2007. "Product Contagion: Changing Consumer Evaluations through Physical Contact with "Disgusting" Products," *Journal of Marketing Research* (44:2), pp. 272-283.

Mugge, R., Schifferstein, H.N., and Schoormans, J.P. 2006. "Product Attachment and Product Lifetime: The Role of Personality Congruity and Fashion," *European Advances in Consumer Research* (7:2), pp. 460-467.

Nah, F.F.-H., Eschenbrenner, B., and DeWester, D. 2011. "Enhancing Brand Equity through Flow and Telepresence: A Comparison of 2d and 3d Virtual Worlds," *MIS Quarterly* (35:3), pp. 731-747.

Nepomuceno, M.V., Laroche, M., Richard, M.-O., and Eggert, A. 2012. "Relationship between Intangibility and Perceived Risk: Moderating Effect of Privacy, System Security and General Security Concerns," *Journal of Consumer Marketing* (29:3), pp. 176-189.

Niedenthal, P.M., Barsalou, L.W., Winkielman, P., Krauth-Gruber, S., and Ric, F. 2005. "Embodiment in Attitudes, Social Perception, and Emotion," *Personality and Social Psychology Review* (9:3), pp. 184-211.

Park, J., Lennon, S.J., and Stoel, L. 2005. "On-Line Product Presentation: Effects on Mood, Perceived Risk, and Purchase Intention," *Psychology & Marketing* (22:9), pp. 695-719.

Peck, J. 2010. "Does Touch Matter? Insights from Haptic Research in Marketing," in *Sensory Marketing: Research on the Sensuality of Products*, A. Krishna (ed.). New York: Routledge, pp. 17-31.

Peck, J., Barger, V.A., and Webb, A. 2013. "In Search of a Surrogate for Touch: The Effect of Haptic Imagery on Perceived Ownership," *Journal of Consumer Psychology* (23:2), pp. 189–196.

Peck, J., and Childers, T.L. 2003. "To Have and to Hold: The Influence of Haptic Information on Product Judgments," *Journal of Marketing* (67:2), pp. 35-48.

Peck, J., and Shu, S.B. 2009. "The Effect of Mere Touch on Perceived Ownership," *Journal of Consumer Research* (36:3), pp. 434-447.

Peck, J., and Wiggins, J. 2006. "It Just Feels Good: Customers' Affective Response to Touch and Its Influence on Persuasion," *Journal of Marketing* (70:4), pp. 56-69.

Petty, R.E., DeSteno, D., and Rucker, D.D. 2001. "The Role of Affect in Attitude Change," in *Handbook of Affect and Social Cognition*, J.P. Forgas (ed.). Mahwah, N.J.: Lawrence Erlbaum Associates Publishers, pp. 212-233.

Radhakrishnan, S., Lin, Y., Zeid, I., and Kamarthi, S. 2013. "Finger-Based Multitouch Interface for Performing 3d Cad Operations," *International Journal of Human-Computer Studies* (71:3), pp. 261-275.

Rempel, D., Camilleri, M.J., and Lee, D.L. 2014. "The Design of Hand Gestures for Human–Computer Interaction: Lessons from Sign Language Interpreters," *International Journal of Human-Computer Studies* (72:10), pp. 728-735.

Russell, J.A. 2003. "Core Affect and the Psychological Construction of Emotion," *Psychological Review* (110:1), p. 145.

Saffer, D. 2008. *Designing Gestural Interfaces: Touchscreens and Interactive Devices*. Sebastopol, Calif.: O'Reilly Media.

Schlosser, A.E. 2003. "Experiencing Products in the Virtual World: The Role of Goal and Imagery in Influencing Attitudes Versus Purchase Intentions," *Journal of Consumer Research* (30:2), pp. 184-198.

Schwarz, N. 2011. "Feelings-as-Information Theory," in *Handbook of Theories of Social Psychology*, P.A.M.V. Lange, A.W. Kruglanski and E.T. Higgins (eds.). Thousand Oaks, CA: Sage, pp. 289-308.

Shen, C., Ryall, K., Forlines, C., Esenther, A., Vernier, F.D., Everitt, K., Wu, M., Wigdor, D., Morris, M.R., and Hancock, M. 2006. "Informing the Design of Direct-Touch Tabletops," *Computer Graphics and Applications, IEEE* (26:5), pp. 36-46.

Spence, C., and Gallace, A. 2011. "Multisensory Design: Reaching out to Touch the Consumer," *Psychology & Marketing* (28:3), pp. 267-308.

Steinmann, S., Kilian, T., and Brylla, D. 2014. "Experiencing Products Virtually: The Role of Vividness and Interactivity in Influencing Mental Imagery and User Reactions," *Thirty Fifth International Conference on Information Systems*, Auckland.

Stevens, J., and Green, B. 1996. "History of Research on Touch," in *Pain and Touch*, L. Kruger (ed.). San Diego: Academic Press, pp. 1-23.

Suh, K.-S., and Lee, Y.E. 2005. "The Effects of Virtual Reality on Consumer Learning: An Empirical Investigation," *MIS Quarterly* (29:4), pp. 673-697.

Sun, H., and Zhang, P. 2006. "The Role of Affect in Information Systems Research," in *Human-Computer Interaction and Management Information Systems: Foundations*, P. Zhang and D.F. Galletta (eds.). Armonk, NY: M.E. Sharpe, pp. 295-329.

Thomson, M., MacInnis, D.J., and Park, C.W. 2005. "The Ties That Bind: Measuring the Strength of Consumers' Emotional Attachments to Brands," *Journal of Consumer Psychology* (15:1), pp. 77-91.

Tsiros, M., and Mittal, V. 2000. "Regret: A Model of Its Antecedents and Consequences in Consumer Decision Making," *Journal of Consumer Research* (26:4), pp. 401-417.

van Beurden, M.H., Ijsselsteijn, W.A., and de Kort, Y.A. 2012. "User Experience of Gesture Based Interfaces: A Comparison with Traditional Interaction Methods on Pragmatic and Hedonic Qualities," in *Gesture and Sign Language in Human-Computer Interaction and Embodied Communication*, E. Efthimiou, G. Kouroupetroglou and S.-E. Fotinea (eds.). Springer, pp. 36-47.

Van der Heijden, H., Verhagen, T., and Creemers, M. 2003. "Understanding Online Purchase Intentions: Contributions from Technology and Trust Perspectives," *European Journal of Information Systems* (12:1), pp. 41-48.

Verhagen, T., Vonkeman, C., Feldberg, F., and Verhagen, P. 2014. "Present It Like It Is Here: Creating Local Presence to Improve Online Product Experiences," *Computers in Human Behavior* (39), pp. 270-280.

Weiss, H.M., Nicholas, J.P., and Daus, C.S. 1999. "An Examination of the Joint Effects of Affective Experiences and Job Beliefs on Job Satisfaction and Variations in Affective Experiences over Time," *Organizational Behavior and Human Decision Processes* (78:1), pp. 1-24.

Xu, J., Benbasat, I., and Cenfetelli, R.T. 2014. "The Nature and Consequences of Trade-Off Transparency in the Context of Recommendation Agents," *MIS Quarterly* (38:2), pp. 379-406.

Yi, C., and Jiang, Z.J. 2015. "Enticing and Engaging Consumers Via Online Product Presentations: The Effects of Restricted Interaction Design," *Journal of Management Information Systems* (31:4), pp. 213-242.

Zhang, P. 2013. "The Affective Response Model: A Theoretical Framework of Affective Concepts and Their Relationships in the Ict Context," *MIS Quarterly* (37:1), pp. 247-274.