Postprint (Accepted manuscript) The Transactions of Human Interface Society, Vol.26, No.1, 2024. (to appear)

Vol.26 No.1, 2024

Original Paper

Perception of psychological ownership and sense of touch through direct and indirect touching of products displayed on a screen

Takashi Mitsuda*1 and Xian Zhang*1

Abstract – **Smartphones and tablets, equipped with touch screens, have revolutionized the way consumers interact with products during online shopping. Touching physical products in stores affects the consumer experience and product evaluation, resulting in an inference of similar effects when touching products through digital devices. However, interacting with products digitally does not always involve the fingers touching the images of a product through a screen; this differs from touching objects physically. This study compared the effects of touch on product evaluation between touching products directly by placing a finger on product images and touching products indirectly using a virtual joystick displayed on a screen. The findings showed that direct touch increases psychological ownership levels, shopping enjoyment, and touch sense than indirect touch. However, the endowment effect was not significantly different. This study also examined the effects of touch on preference through a two-alternative forced choice task between items involving direct and indirect touch conditions. The results showed that items touched directly were chosen more frequently, thereby suggesting increased preference levels for items through direct touch. These results suggest that forms of interactive contact with objects using a touch screen affect user experience and object valuation.**

Keywords : **touch, haptics, psychological ownership, preference, touch screen**

1. Introduction

In conventional in-store shopping environments, touching products not only conveys tactile information to consumers, but it also increases evaluation levels [1], [2] and their likelihood of choosing a particular product [3], [4]. Online shopping does not allow users to touch products physically. However, during online shopping using touch-panel-equipped devices, such as smartphones and tablets, users can touch the images of the products displayed on the screen to select them for purchase, magnify the view, access the selected products' detailed information, or rotate the images to view the products' three-dimensional appearances. These experiences involve touching products via touch screens, and multiple studies have investigated the effects of these touch experiences on product evaluation [5]~[9]. However, the forms of touching product images using digital devices are diverse, and investigations of their impact on product valuation remain limited.

This study focuses on whether a finger is placed on a product image displayed on a touch screen. Touching objects physically always involves tactile and visual feedback. However, swiping across or touching images displayed on a touch screen involves tactile contact with the screen but not necessarily visual contact with the products. Nevertheless, touching or swiping the screen (even if it is not on the product image) also changes the information displayed, and allows interaction with a product. Touching an object by placing a finger on its image on a screen (i.e., direct touch) or away from it (i.e., indirect touch) may have different impacts on the psychological effects involved. In this study, three experiments were conducted to investigate the effects of both the direct and indirect touching of product images on user experience and object evaluation.

2. Literature review and hypotheses

2.1 Touch, psychological ownership and the endowment effect

When shopping in stores, consumers who are highly motivated to touch the products displayed for sale experience increased levels of frustration and decreased levels of confidence during product evaluation when they cannot touch such products [10]. The psychological mechanism, which results in an increased evaluation of products through the touch experiences, has been investigated with psychological

*1: Graduate School of Information Science and Engineering, Ritsumeikan University

ownership [11] and the endowment effect [12].

Psychological ownership is the feeling of possession regardless of legal ownership [11]. The sense of ownership emerges not only with regard to physical objects but also non-physical entities, such as ideas and organizations. Touching products physically not only provides consumers with haptic information but also increases the levels of psychological ownership [13].

The endowment effect is the tendency to value objects owned by an individual. The monetary amount necessary to acquire a product (willingness to pay; WTP) becomes less than the amount required to give it away (willingness to accept; WTA) [12]. Psychological ownership enhances the endowment effect [14]. Consequently, touching products physically can increase the value of a product through psychological ownership and the endowment effect as the mediating variables [13], [15].

The effect of product valuation through touch depends on the importance of the haptic information associated with touching a product [1], [2], [16], thereby suggesting that the touch diagnostics involved mediate product valuation levels. However, the level of psychological ownership increases through physical touching as well as touch imagery [17] or observing images of the touched products [18]. Perceptual studies outside marketing research have also demonstrated the effects of touch on object evaluation. The more often an object is touched, the more preferred it is [19], [20]. This effect is enhanced through voluntary hand movements, regardless of the haptic information involved [21]. When people choose a favorable item, they tend to choose the item they touched last [22]. These findings also suggest that touching an object has psychological effects during preference judgment, regardless of the tactile information provided.

2.2 Psychological effects induced through touching digital devices

When using devices equipped with touch panels, users manipulate the images displayed on the screen through touch using their fingers. Touching the displayed images does not offer any tactile information regarding the products. However, previous studies have shown that touching the product images displayed increases psychological ownership levels and the endowment effect. Nevertheless, some conflicts across these studies remain (see Table 1 for a review of the studies on touching digital devices).

Table 1. Reviews of studies on touching digital devices.

Studies	Devices and operations	Psychological ownership	Endowment effect
Brasel & Gips (2014)	Computer mouse vs. touch (Selecting a product for viewing)	Significant	Significant
deVries et al. (2018)	Computer mouse vs. touch* (Rotation)	n.s.	n.s.
	Touch panel (Rotation vs. Zoom-in)	Significant	n.s.
Brengman et al. (2019)	Computer mouse vs. touch** (Browsing a website)	n.s.	-
This study	Touch panel (Direct vs. Indirect touch)	Significant	n.s.

Note . *Touch pad or **augmented reality were also compared.

Brasel and Gips [5] established that when users touched displayed product images using their fingers, they experienced increased levels of psychological ownership, the endowment effect, and the valuation of items than when they used a computer mouse for similar operations. However, de Vries et al. [8] did not detect any significant differences in psychological ownership levels and the endowment effect between the two touching methods. Brengman et al. [7] compared the characteristics of browsing a product website using fingers, a computer mouse, and augmented reality (AR) applications in which users observe product images in a real-world environment. The results showed that psychological ownership levels increased when using AR applications. However, no differences between finger and computer mouse operations were observed. Accordingly, the effects of touching a screen on psychological ownership levels varied across these studies.

A possible reason behind the discrepancies between these studies is the different operations on a screen (e.g., touch and swipe). De Vries et al. [8] compared touching a displayed item to zoom in (i.e., two-dimensional) and rotating an item on the screen using a finger (i.e., three-dimensional), expecting that the latter provides additional information regarding the items displayed. The results showed that rotating items resulted in increased levels of psychological ownership and item valuation. However, no differences in the endowment effect were found.

2.3 Effect of having finger contact with images of products

Another possible reason behind the discrepancies between the previous studies is the effect of placing a finger on the image of a product. De Vries et al. [8] used Shoogleit scrunch technology [23] to rotate objects on the screen horizontally when swip-

ing across a touch screen. Through this technology, swiping across a screen without placing a finger on the objects displayed also rotates them. Essentially, the motive for possession significantly involves being in control [11]. Therefore, moving objects without touching them would have emerged as a sense of control, thereby resulting in increased levels of psychological ownership. However, merely touching actual items also results in the aspect of psychological ownership [13]. Consequently, we propose the following hypothesis:

H1: Moving items on a screen by touching them (i.e., placing a finger on the objects) results in increased levels of psychological ownership compared to moving such items by touching sections of the screen that are outside the objects.

This study focused on the effects of touching product images displayed on a screen. We call moving items on a screen by touching them "direct touching" and by touching sections of the screen outside the objects "indirect touching" in this study. Additionally, the findings of the study conducted by Brasel and Gips [5] and those of the studies examining the effects of touching products physically(e.g., [13]) suggest that the psychological ownership increased by touching product images led to the following hypotheses:

H2: Directly touching items displayed on a touch screen results in the increased monetary value of the touched items compared to indirect touch.

H3: Directly touching items displayed on a touch screen enhances the endowment effect than indirect touch.

The sense of touching experienced in stores increased the enjoyment consumers got from shopping [10]. Similarly, touching products on a touch panel provided higher shopping enjoyment than touching them using a computer mouse [8]. Thus, we also expected the following:

H4: Directly touching items displayed on a touch screen results in increased levels of shopping enjoyment than indirect touch.

The effect of touching an image displayed on a screen on psychological ownership may also be modulated by the interactivity of the displayed products [5]. High interactivity enhances the vividness of the displayed product [24]. In turn, the resulting imagery vividness of the product can affect perceived ownership [17]. The sense of touch may also modulate psychological ownership because touch imagery [17] or observing images of the products being touched [18] also increased the level of psychological ownership. The sensations experienced through the touch, including object interactivity and feeling of touch, were higher when touching products on a touch panel, compared with touching using a computer mouse [8]. Therefore, we expected the following:

H5: Directly touching items displayed on a touch screen results in higher touch sensations than indirect touch.

This study tested the above hypotheses in the tasks involving the three-dimensional rotation and observation of items displayed on a screen by touching them directly with a finger (i.e., direct touching), or by manipulating the joystick button displayed on the screen below the product image (i.e., indirect touching).

3. Experiment 1

Experiment 1 compared the levels of psychological ownership and valuation when the participants assessed the items displayed on a tablet screen by touching and rotating them using their fingers (direct condition) and by rotating them using a virtual joystick displayed on the screen without touching the items (indirect condition). In this experiment, the participants selected the item they liked best from images of eight apples (or bananas) displayed on the screen, after which they responded to the prices of the selected items and answered a questionnaire regarding their choices.

3.1 Method

3.1.1 Participants

Thirty-two students from a university (mean age: 22.4 years, SD = 1.5; 25 males and seven females) volunteered for the experiment. All the participants provided written informed consent.

3.1.2 Apparatus

The participants sat on a chair and manipulated the screen of a tablet computer (Surface Pro 7, Microsoft) with a 12.3" screen (260 mm × 170 mm, with a resolution of 2736 × 1824 pixels) placed on a table. The experiment was conducted using custom software running on a virtual reality platform (Unity, version 2019.4.5f1).

Figure 1. 3D models created by digitally scanning real apples and those of bananas obtained from commercially available models.

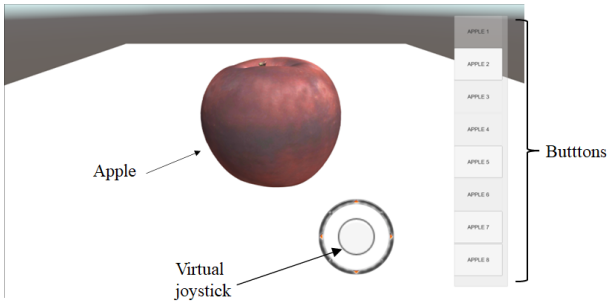


Figure 2. The screen presented to participants in Experiment 1.

3.1.3 Stimuli

Three-dimensional digital models of eight apples and eight bunches of bananas with different shapes, colors, and maturity levels were used in the experiment, as shown in Figure 1. The 3D models of apples were created by digitally scanning real apples, whereas those of bananas were obtained from commercially available models.

3.1.4 Procedure

Figure 2 shows the screen presented to the participants. Figure 3 depicts the procedure of a single trial. A single item placed on the table was displayed at the center of the screen, and buttons corresponding to the eight items were displayed on the right side. Pressing these buttons switched the items displayed at the center of the screen. The participants pressed these buttons in any order, for any number of times, with no time limit. They wished for and verbally responded to the item they liked best through its number.

In the direct condition, the participants placed their fingers on an item and swiped across it to rotate the item. The item rotated in all directions in response to the movement of their fingers. The rotation of the item's image stopped when the fingers were removed from the screen.

In the indirect condition, the participants placed their fingers on the virtual joystick (a circular button with a diameter of 15 mm, which was placed inside a circle with a diameter of 26 mm) displayed in the lower right corner of the item, and they swiped across it to rotate the displayed item. The item's image rotated in all directions similar to the direct condition. When the finger movements were identical, the rotation of the item's image was identical across both conditions. When the finger was removed from the screen, the rotation of the item's image stopped, and the button for the virtual joystick returned to the center of the circle.

To enable the participants to identify the buttons that were yet to be pressed, the color of the pressed buttons changed, and an exit button appeared at the bottom of the screen once all the buttons had been pressed. Regardless of the indication of the exit button, the participants were allowed to press the buttons and observe the items' images as many times as they wished until they made their selection. When the participants determined their selection, they pressed the exit button and verbally responded with the number of the selected items, followed by the amount they were willing to pay for the item (WTP) and the amount they would accept to give the item away if they owned it (WTA). As shown in the Appendix, the participants then answered the questionnaires regarding psychological ownership, shopping enjoyment, and sensations associated with touch using a 7-point Likert scale ranging from "not at all"(disagree) (-3) to "very much" (agree) (+3). The questions were created in Japanese with reference to previous studies [8], [17], [25]. Some questions translated from the original were modified or deleted because they seemed difficult to understand or distinguish from the other questionsinquiries. After all the questions were answered, the participants performed the next trial after a 10-minute break.

3.1.5 Task design

Experiment 1 employed a crossover design involving two types of touch (direct and indirect). The participants performed four trials within two weeks: two in the direct condition and two in the indirect condition. During week 1, the participants completed one trial involving the selection of one out of eight apples (or bananas) in the direct condition and another trial involving the selection of another fruit (apple or banana) in the indirect condition. During week 2, the combination of the fruits and the contact conditions involved were reversed from those of week 1, and the same task was performed using the same items. The

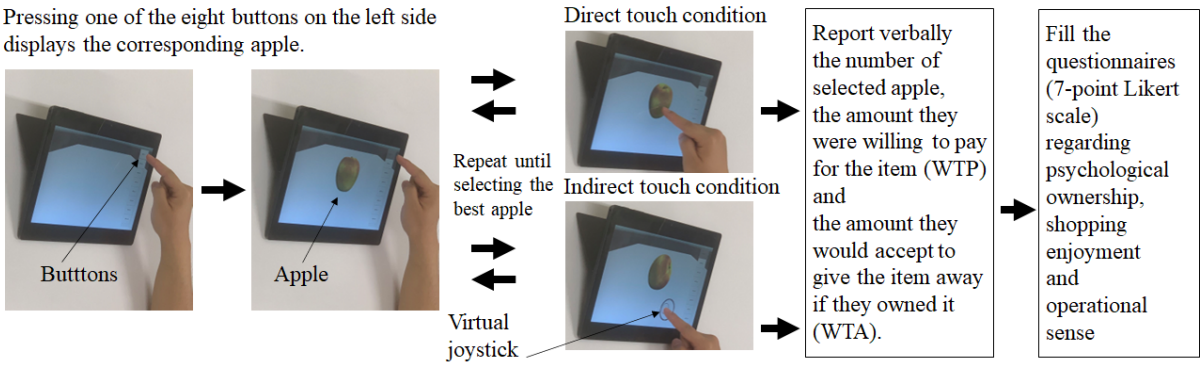


Figure 3. Procedure of a single trial in Experiment 1.

order of the four trials was counterbalanced among the participants. Before the evaluation, the participants practiced the task to familiarize themselves with the operations involved. The experiment took approximately 30 min, including practice time.

3.2 Results and discussion

In most trials, participants observed several items repeatedly to compare after selecting all the items once. Figure 4 shows the distribution of the average number of times an item was selected for observation. On average, the number of buttons pressed for each item was 1.98 (SEM = 0.15) in the direct condition and 1.76 (SEM = 0.15) in the indirect condition. The numbers did not differ significantly between both conditions (t (31) = 1.26, p = .22, r = .22). The duration until decision-making was 63.2 s (SEM = 4.7) in the direct condition and 58.6 s (SEM = 3.8) in the indirect condition, which did not significantly differ for both conditions (t (31) = 1.52, p = .14, r = .26).

The results of the questionnaire are presented in Figure 5. Cronbach's coefficient alpha for psychological ownership, shopping enjoyment, and touch sensations were 0.87, 0.81, and 0.56, respectively. Regarding sensations associated with touch, Cronbach's coefficient alpha did not surpass 0.8 even if any one of the three items in the questionnaire were deleted. Therefore, we analyzed sensations associated with touch for each question item and psychological ownership and shopping enjoyment by their average ratings. The Wilcoxon signed-rank test showed that the levels of psychological ownership (z = 2.2, p =.025, r =.40), shopping enjoyment (z = 2.1, p =.040, r =.36), texture (z = 2.2, p = .029, r =.39), and feeling of touch (z = 3.9, p < .001, r =.69) were all significantly higher in the direct condition than the indirect condition. No significant difference was observed between the conditions for object interactivity (z = 0.7, p = .48, r =.13).

Spearman's rank correlation coefficients showed that the levels of psychological ownership, shopping enjoyment, and sensations associated with touch were significantly correlated under the direct and indirect conditions, except some correlations between items of touch sensations, as shown in Table 2. Psychological ownership was highly correlated with the feeling of touch in both the conditions. In turn, shopping enjoyment was highly correlated with the texture and object interactivity in direct touch condition.

Table 3 shows the WTP, WTA, and ratios for each condition and each fruit. Three-way repeated measures analysis of variance for the two touch conditions (direct vs. indirect), two assessment amounts (WTP vs. WTA), and two fruits (apple vs. banana) showed significant differences between the assessment amounts (F(1,31) = 18.5, p <.001, *partial* η^2 = .37) and between fruits (F(1,31) = 17.5, p <.001, *partial* η^2 = .36). However, no significant differences were observed between the touch conditions (F(1,31) = 1.33. , p =.26). The Wilcoxon signed-rank test showed that the endowment effect (WTA/WTP) did not differ significantly between the touch conditions for apples (p =.74) and bananas (p =.16). The WTP, WTA, and endowment effect were not significantly correlated with psychological ownership (ps > .45).

This experiment shows that directly touching the items displayed for rotation significantly increased the levels of psychological ownership, shopping en-

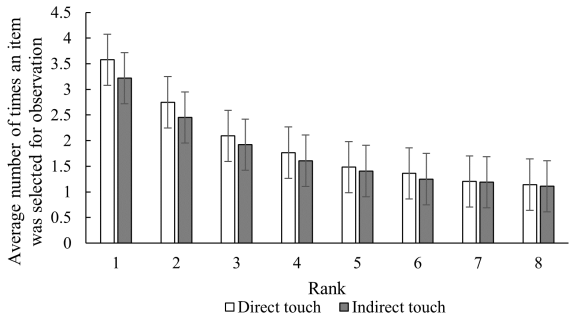


Figure 4. The average number of times an item was selected for observing. The error bars show the stadard deviation.

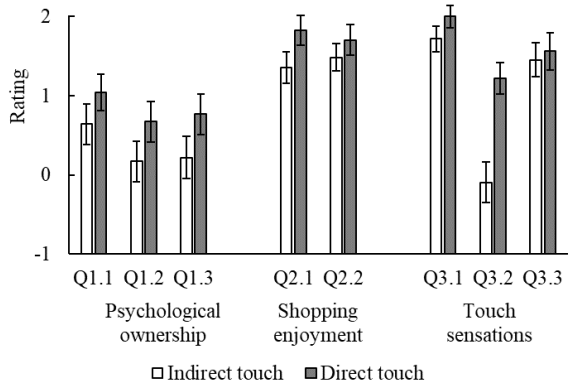


Figure 5. Effects of psychological ownership, enjoyment of shopping, and sensations associated with touch through touching methods. The error bars show the standard error of the mean.

Table 2. Correlation matrix. The values in the upper and lower triangle are for indirect and direct touch conditions, respectively.

	Psychological ownership	Shopping enjoyment	Touch sensations Q3.1	Q3.2	Q3.3
Psy. ownership	-	.48**	.36*	.75***	.51**
Enjoyment	.49**	-	.36*	.55**	.59***
Q3.1 Texture	.44*	.76***	-	.38*	.33
Q3.2 Feel of touch	.68***	.37*	.21	-	.53**
Q3.3 Interactivity	.53**	.75***	.71***	.56***	-

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

Table 3. Valuations of fruits assessed through the direct and indirect touch conditions as well as the ratios of WTP and WTS (Japanese Yen).

Valuation	Fruit	Direct touch (SEM)	Indirect touch (SEM)
WTP	Apple	149.6 (14.3)	138.6 (10.0)
	Banana	230.9 (24.6)	219.5 (26.0)
WTA	Apple	187.8 (19.5)	173.7 (13.7)
	Banana	315.3 (36.7)	295.3 (47.5)
WTA/WTP	Apple	1.30 (0.07)	1.27 (0.05)
	Banana	1.38 (0.07)	1.30 (0.04)

joyment, compared to indirect touch using a virtual joystick. Non-significant difference in object interactivity between the two conditions and a high correlation between the feeling of touch and psychological ownership indicates that psychological ownership was mainly enhanced by the sense of touching images of products.

However, contrary to the hypotheses, the differences in the valuation of items and the endowment effect between the direct and indirect touching conditions were not confirmed. This may be due to significant individual differences in pricing. The WTP for apples fluctuated between 60 and 300 Japanese yen and that for bananas between 70 and 800 Japanese yen. To verify the differences in the valuation of items between the two touching methods, the next experiment employed a two-alternative forced choice task in which participants compared the touched and non-touched items without assessing the prices.

4. Experiment 2

In Experiment 2, the participants chose the apple they liked better from the two options presented on the screen. They observed one of the two apples by touching and rotating it using their fingers (direct touch) and the other by rotating it using a virtual joystick (indirect touch). This experiment identified the apple that was chosen more frequently in the direct and indirect touch conditions. Products touched on a touch panel were more frequently chosen than those touched using a computer mouse [26], [27]. Based on the findings of increased levels of psychological ownership for the object touched directly in Experiment 1, we predicted the following:

H6: Items touched directly on a touch screen are preferred over those touched indirectly.

4.1 Method

4.1.1 Participants

Twenty-four students from a university (average age: 22.8 years, 20 males and 4 females) that did not participate in Experiment 1, participated in the second experiment. All the participants volunteered for the experiment, and they provided written informed consent.

4.1.2 Apparatus and stimuli

The same tablet computer and custom software used in Experiment 1 were used in this second experiment. Three-dimensional scanned models of 30 apples of different sizes, colors, and maturity levels were used in this experiment.

4.1.3 Procedure

Figure 6 shows the screen presented to the participants. At the beginning of the trials, two items were presented side-by-side on a table. The participants first rotated and observed the item presented on the left side for 30 s in the direct or indirect touch con-

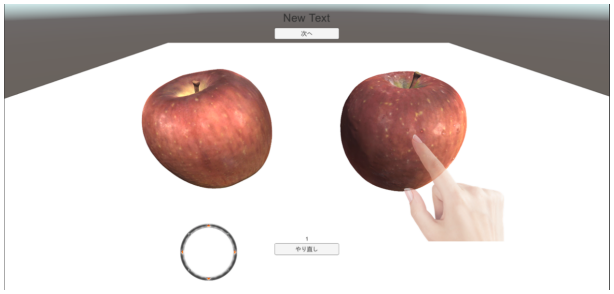


Figure 6. The screen presented to the participants in Experiment 2. The participants rotated the image of an apple using their fingers and rotated the image of the other apple using a virtual joystick before selecting the item they liked better.

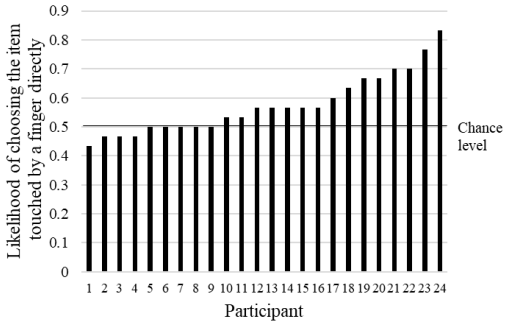


Figure 7. The likelihood of selecting the items touched using fingers in Experiment 2

ditions, after which they rotated and observed the item image presented on the right side for 30 s in the other contact method before verbally showing the item they preferred. The item images were rotated in a manner similar to that employed in Experiment 1, consistent with finger movements. The participants adjusted the duration for touching each item image based on the time displayed at the top of the screen. After responding, the participants were asked to press the button for the next trial as soon as they were ready.

4.1.4 Task design

Experiment 2 employed a crossover design involving two types of touch (direct and indirect). The participants performed 30 trials involving the selection of one out of two apples, whereby one was observed in the direct touch condition, and the other was observed in the indirect touch condition. In the first 15 trials, the participants compared 15 image pairs created from 30 apples. In the remaining 15 trials, the same 15 pairs were compared in the same order but with reversed touch assignments for each apple (direct and indirect touch conditions). Accordingly, the effects of the differences in the attractiveness of the two apples in each pair upon selection were counterbalanced. The order of the direct and indirect touch conditions was switched alternately for each trial. The left-right placement and the order of contact methods were counterbalanced among the participants. The participants practiced rotating the dummy item images prior to evaluation. The total time required for the experiment, including practice time, was approximately 45 min.

4.2 Results and discussion

Figure 7 shows the likelihood of choosing an item in the direct touch condition for each participant. The average of this likelihood was 0.58 ($SEM = 0.02$), which was significantly larger than the chance level ($t\,(23) = 3.58$, $p = .001$, $r = .60$). The binomial test involving all the trials among the participants ($N = 720$) also showed a significant likelihood of selecting the touched apples ($p < .001$).

This experiment shows that the apple images rotated by placing a finger on the screen were preferred over those rotated using a virtual joystick, which supported Hypothesis 6. To verify the increased preference for touched items, we conducted the same task using other types of objects in the next experiment.

5. Experiment 3

The apples used in Experiment 2 were products that could be rotated manually. In Experiment 3, the tasks performed in Experiment 2 were conducted using 3D models of houses to verify whether the differences in contact methods affected the choices made, even for products that could not be rotated manually. Additionally, we asked the participants to complete a questionnaire regarding object interactivity to check if the difference between the two touch conditions modulated their choice.

5.1 Method

5.1.1 Participants

Thirty-two students from a university (average age: 22.8 years, 28 males and four females) who did not participate in Experiments 1 and 2 volunteered for the experiment and provided written informed consent.

5.1.2 Apparatus and stimuli

The same tablet computer and software used in Experiment 2 were employed for this experiment. Thirty-two pairs of houses, which were created using 64 commercially available 3D models of a single house, were used in this experiment (Figure 8).

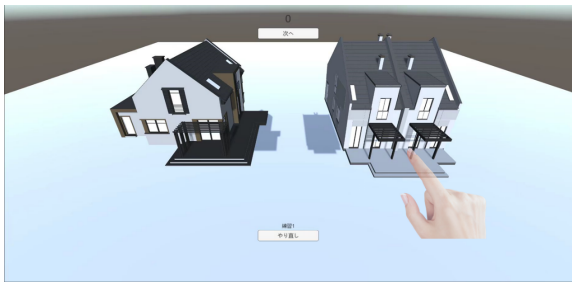


Figure 8. 3D models of a house presented in Experiment 3.

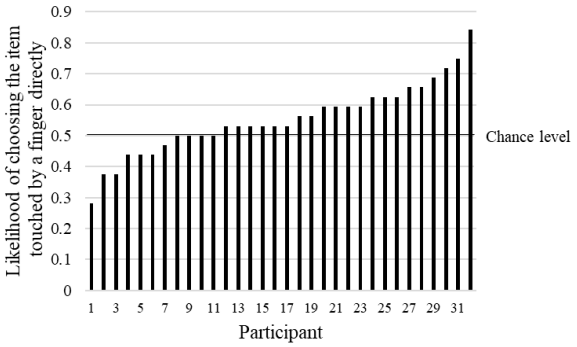


Figure 9. The likelihood of selecting the item touched using a finger directly in Experiment 3

5.1.3 Procedure

The procedure was almost similar to that involving Experiment 2, with the following two changes. First, the duration for touching each item was reduced from 30 s to 20 s. This was because the participants in Experiment 2 commented that 30 s of contact was too long to make a preferential decision. Next, after completing all the trials, using a 7-point scale ranging from -3 (no) to 3 (yes), the participants were asked to indicate whether they felt as if they could move the items as they wished throughout each of the touch methods.

5.1.4 Task design

In Experiment 2, the participants evaluated 15 pairs of apples twice to counterbalance the effects of the differences in attractiveness between the two apples in each pair. In Experiment 3, the participants evaluated 32 pairs of houses only once. The combination of the houses presented and the contact methods were counterbalanced among the participants. This change was conducted because, if the pairs of houses were presented twice, the participants may have remembered the first choice, and this aspect may have affected the second choice. Compared to those of apples, there were significant individual differences in the appearances of houses, thereby making it easy to remember. The experiment took approximately 45 min, including practice time.

5.2 Results and discussion

The likelihood of choosing the houses in the direct touch condition was 0.55 ($SEM = 0.02$), which was significantly higher than the chance level of 0.5 ($t\,(31) = 2.66$, $p = .01$). Figure 9 shows the likelihood of choosing for each participant. The binomial test involving all trials among the participants ($N = 1024$) also showed a significant likelihood of selecting the touched items ($p < .001$). No significant differences were observed between this likelihood and that for Experiment 2 ($t\,(54) = 0.75$, $p = .46$).

The mean ratings for object interactivity were 1.81 ($SEM = 0.24$) and 1.31 ($SEM = 0.19$) for the direct and indirect touch conditions, respectively. Contrary to the result of Experiment 1, the direct touch condition provided the participants with significantly greater object interactivity than the indirect touch condition (Wilcoxon signed-rank test, $p = .035$, $r = .37$). To verify the effect of object interactivity on the likelihood of choosing the items touched, the difference in the rating of object interactivity between the two touch conditions was assessed for each participant. However, Spearman's rank correlation was not significant between the difference in object interactivity and the likelihood of choosing the touched item ($r = .29$, $p = .10$). Although 69% (22/32) of the participants rated the direct touch condition as providing enhanced object interactivity than the indirect touch condition, 22% (7/32) of the participants rated the indirect touch condition as better. The likelihoods of selecting the houses in the direct touch condition were 0.574 ($SEM = 0.023$) for the former participants and 0.509 ($SEM = 0.047$) for the latter participants.

The results of Experiment 3 show that the houses rotated by placing a finger on the screen were highly preferred compared to those rotated using a virtual joystick. Therefore, the increased preference for the items touched using fingers, as observed in Experiments 1 and 2, is not limited to fruits or handheld items.

6. General discussion

This study compared the levels of psychological ownership, product value, the endowment effect, shopping enjoyment, and sensations associated with

touch when images of products displayed on a touch screen are directly rotated using a finger and when a virtual joystick is used to rotate the items displayed indirectly. Consistent with the hypotheses associated with this study, the experiments' results showed increased levels of psychological ownership (H1), shopping enjoyment (H4), and preference (H6) for the items rotated directly using a finger. The increased level of psychological ownership was highly correlated with the sense of touch. However, no significant differences in the values paid for the items were detected between both touch conditions, thereby rejecting hypothesis H2. Additionally, no significant differences in the endowment effect were detected between the touch conditions (H3). The hypothesis (H5) regarding sensations associated with touch was partially accepted. The feeling of touch and texture of the product were significantly higher when placing a finger on the product than outside of it. However, Experiment 1 and Experiment 3 gave dissimilar results for object interactivity.

6.1 Psychological ownership

A previous studies [8] employing touch operations similar to those applied in this study (i.e., rotating items for observation) showed that the psychological ownership levels associated with items touched using a finger were not significantly different from those associated with items rotated using a computer mouse. As described in the introduction, touching a screen outside of products may have affected the results in the previous study. Other various aspects also support the reasons why this study demonstrated significant differences in the psychological ownership levels associated with both direct and indirect touch conditions involving tablets. First, visual information regarding the touching of objects may have affected the levels of perceived ownership. In manipulations involving a computer mouse, a cursor appears on the screen and overlaps with the displayed item. However, in indirect touch conditions using a virtual joystick, there was no visual mark that overlapped the displayed item, and this may have impaired the sense of touch and decreased the levels of psychological ownership. Second, the degree of the need to rotate the displayed items may have affected the levels of psychological ownership. The items used in the aforementioned study involve significant differences in the appearances between items, and this attribute may have decreased the importance of rotating the items. However, the experiments associated with this study involved the use of apple and banana images with slightly different colors and shapes. Therefore, there would have been an increased need to rotate them to assess the appearance of the items. The impacts of touching items on psychological ownership levels may also be affected by the information provided through touch.

6.2 Monetary value and the endowment effect

In this study, there were no differences in the endowment effect between the direct touch and indirect touch conditions on a touch screen. The conflicts across previous studies may be as a result of different categories of the items used in the experiments. Such items include shirts, tents, and city tours, in the study conducted by Brasel and Gips [5] and packaged drinks and sausages in the study conducted by de Vries [8] as well as the apple and banana images used in the experiments associated with this study. This study found significant individual differences in the assessed prices of apples and bananas, thereby suggesting the influence of the purchase experience. Additionally, for fruits, it may have been difficult to assess the price only from appearance.

This study also involved some claims from the participants, arguing that it was difficult to assess the prices required to give apples and bananas away (WTA). The difficulties involving pricing also indicate the need for an alternative method for measuring the endowment effect without price assessment, such as exchanges between two items [12]. This study employed a two-alternative forced choice task involving selecting items through a direct touch condition and an indirect touch condition, which does not require pricing. The increased preference of items in the direct touch condition indicates an enhanced valuation of the items selected.

Another possible reason for the discrepancy between the studies on the endowment effect is the influence of cultural [28] and gender differences [29]. The participants in this study were either Japanese or Chinese students studying at a Japanese university, and the majority of the participants were male. Maddux et al. [28] showed a smaller endowment effect for East Asians compared with Westerners. Iseki et al. [30] showed the levels of psychological ownership

were not correlated with monetary value in Japanese participants, which coincides with the result of this study. Therefore, individual differences should be investigated with more diverse participants in future studies.

6.3 Sensations associated with touch

This study found that when rotating items on the screen through direct touch, feelings of touch and texture were higher than those achieved through indirect touch. High correlation between the sense of touch and levels of psychological ownership demonstrated the impact of having finger contact with a product image.

Object interactivity did not differ significantly between touch conditions in Experiment 1; however, they varied in Experiment 3. The number of touched objects in each touch condition before evaluating object interactivity was eight in Experiment 1 and 32 in Experiment 3. Therefore, the difference in the degree of experience through direct and indirect touch may have contributed to the difference. Virtual joysticks are frequently used in games designed for smartphones or tablets. Therefore, the experience of using a virtual joystick may also have affected the levels of object interactivity. Accordingly, it is necessary to investigate the characteristics of users on digital devices.

Perception of object interactivity—the degree of controlling objects as they want—has been considered as a source of psychological ownership [11], [17]. Iseki et al. [30] showed a significant correlation between perceived control and psychological ownership, which was also observed in this study. The difference in object interactivity between touch conditions in this study was much smaller than previous studies, because the participants in this study were able to control items as they want roughly in both the touch conditions. Accordingly, the effect of object interactivity through digital devices to psychological ownership should be investigated in conditions with more control over user experience and interactivity.

6.4 Shopping enjoyment

Shopping enjoyment was highly correlated with object interactivity in the direct touch condition, which coincides with many studies using digital devices (e.g., [31]). Shopping enjoyment was also correlated with psychological ownership in this study. The shopping enjoyment induced by touching accompanied psychological ownership for physical [10] and online shopping [8] in other studies too. Ownership, in its origin, is thought to be associated with pleasure [11]. Consumers feel happier when they have higher psychological ownership over an item after consumption [32]. These results suggest a close relationship between shopping enjoyment and psychological ownership.

6.5 Limitations and Directions for Future Research

This study involved within-subjects design experiments in which each participant repeated the trials, rather than experiments designed for shopping. Therefore, this study may have detected the differences between touch conditions more sensitively than previous studies. Additionally, the participants' imagination of the research purpose may have affected their performance. The effect would have been small because it was not clear whether direct or indirect touch was the control task. However, the impact of finger contact on the image of a product should also be verified in between-subject design experiments.

Future studies involving a wider demographic range of participants are also required to assess the influences of the desire to touch objects as well as the experience of using digital devices. Individual differences in the desire to touch products, which is known as the need for touch (NFT), impact the effect of touch on the confidence levels associated with evaluation [33], purchase intent [34], and product valuation [1], [35].

Investigating the effects of item attributes is also crucial. Brasel and Gips [5] showed that the psychological ownership of products with low haptic importance (city tours) was also higher in direct touch operations than in operations involving a computer mouse. However, the differences were fewer than those involving products with high haptic importance (sweatshirts). Therefore, the difference between direct and indirect touch conditions for items that cannot be touched is an interesting topic for future studies.

Van Kerrebroeck et al. [36] showed that although consumer adoption seems to be a necessity, handling items while wearing a data glove could provide consumers with utilitarian and hedonic values. Mitsuda and Wang [37] showed that items handled virtually

through hands using a motion capture system (i.e., virtual reality technology) were more likely to be chosen than those handled using a computer mouse. Many studies have begun to investigate the role of shopping using head-mounted displays [38], [39]. The psychological impacts of touching items using new digital devices should be investigated further.

7. Conclusions

This study involved three within-subject design experiments aimed at comparing user experience and item valuation through rotating images on a touch screen by directly touching the images using a finger or by using an on-screen virtual joystick. The experiments' results showed that directly touching the items displayed yielded increased levels of psychological ownership, shopping enjoyment, sense of touch and texture, and preference, compared to indirectly touching the items displayed. However, no significant differences in the endowment effect were observed between the touch conditions involved.

This study shows that the touching style used through a touch screen, and whether the finger is over the item on the screen modulates the psychological effects associated with the displayed items. Touching items on a screen involves tactile, visual, and interactive feedback. The correlation between these sensations and their psychological effects is required to assess the psychological effects of displayed items that consumers interact with using new digital devices.

Disclosure statement

The authors have no competing interests to declare with the findings of this study.

Reference

[1] Grohmann, B., Spangenberg, E. R., and Sprott, D. E.: The influence of tactile input on the evaluation of retail product offerings. *Journal of Retailing*, Vol. 83, pp. 237–245(2007).

[2] McCabe, D. B., and Nowlis, S. M.: The effect of examining actual products or product descriptions on consumer preference. *Journal of Consumer Psychology*, Vol. 13, pp. 431–439(2003).

[3] Streicher, M. C., and Estes, Z.: Touch and go: merely grasping a product facilitates brand perception and choice. *Applied Cognitive Psychology*, Vol. 29, pp. 350–359(2015).

[4] Streicher, M. C., and Estes, Z.: Multisensory interaction in product choice: grasping a product affects choice of other seen products. *Journal of Consumer Psychology*, Vol. 26, pp. 558–565(2016).

[5] Brasel, S. A., and Gips, J.: Tablets, touchscreens, and touchpads: how varying touch interfaces trigger psychological ownership and endowment. *Journal of Consumer Psychology*, Vol. 24, pp. 226–233(2014).

[6] Brasel, S. A., and Gips, J.: Interface psychology: touchscreens change attribute importance, decision criteria, and behavior in online choice. *Cyberpsychology, Behavior and Social Networking*, Vol. 18, pp. 534–538(2015).

[7] Brengman, M., Willems, K., and Van Kerrebroeck, H.: Can't touch this: the impact of augmented reality versus touch and non-touch interfaces on perceived ownership. *Virtual Reality*, Vol. 23, pp. 269–280(2019).

[8] de Vries, R., Jager, G., Tijssen, I., and Zandstra, E. H.: Shopping for products in a virtual world: why haptics and visuals are equally important in shaping consumer perceptions and attitudes. *Food Quality and Preference*, Vol. 66, pp. 64–75(2018).

[9] Mulcahy, R. F., and Riedel, A. S.: ' Touch it, swipe it, shake it': does the emergence of haptic touch in mobile retailing advertising improve its effectiveness? *Journal of Retailing and Consumer Services*, Vol. 54, 101613(2020).

[10] Peck, J., and Childers, T. L.: To have and to hold: the influence of haptic information on product judgments. *Journal of Marketing*, Vol. 67, pp. 35–48(2003).

[11] Pierce, J. L., Kostova, T., and Dirks, K. T.: The state of psychological ownership: integrating and extending a century of research. *Review of General Psychology*, Vol. 7, pp. 84–107(2003).

[12] Kahneman, D., Knetsch, J. L., and Thaler, R. H.: Experimental tests of the endowment effect and the Coase theorem. *Journal of Political Economy*, Vol. 98, pp. 1325–1348(1990).

[13] Peck, J., and Shu, S. B.: The effect of mere touch on perceived ownership. *Journal of Consumer Research*, Vol. 36, pp. 434–447(2009).

[14] Reb, J., and Connolly, T.: Possession, feelings of ownership and the endowment effect. *Judgment and Decision Making*, Vol. 2, pp. 107–114(2007).

[15] Shu, S. B., and Peck, J.: Psychological ownership and affective reaction: Emotional attachment process variables and the endowment effect. *Journal of Consumer Psychology*, Vol. 21, pp. 439–452(2011).

[16] Marlow, N., and Jansson-Boyd, C. V.: To touch or not to touch; that is the question. Should consumers always be encouraged to touch products, and does it always alter product perception? *Psychology and Marketing*, Vol. 28, pp. 256–266(2011).

[17] Peck, J., Barger, V. A., and Webb, A.: In search of a surrogate for touch: the effect of haptic imagery on perceived ownership. *Journal of Consumer Psychology*, Vol. 23, pp. 189–196(2013).

[18] Luangrath, A. W., Peck, J., Hedgcock, W., and Xu, Y.: Observing product touch: the vicarious haptic effect in digital marketing and virtual reality. *Journal of Marketing Research*, Vol. 59, pp. 306–326(2022).

[19] Jakesch, M., and Carbon, C. C.: The mere exposure effect in the domain of haptics. *PLOS ONE*, Vol. 7, e31215(2012).

[20] Mitsuda, T., and Yoshioka, Y.: Final sampling

bias in haptic judgments: how final touch affects decision-making. *Perception*, Vol. 47, pp. 90–104(2018).
[21] Mitsuda, T., Luo, J., and Wang, Q.: Exploratory hand movements enhance the liking effect in haptics. *Perception*, Vol. 48, pp. 850–861(2019).
[22] Mitsuda, T., and Yoshioka, Y.: Taken last, selected first: the sampling bias is also present in the haptic domain. *Attention, Perception and Psychophysics*, Vol. 77, pp. 941–947(2015).
[23] Padilla, S., and Chantler, M. J.: Shoogleit.com: engaging online with interactive objects. *Digital Engagement*, 11(2011).
[24] Schlosser, A. E.: Experiencing products in the virtual world: The role of goal and imagery in influencing attitudes versus purchase intentions. *Journal of Consumer Research*, Vol. 30, pp. 184–198(2003).
[25] Overmars, S., and Poels, K.: A touching experience: Designing for touch sensations in online retail environments. *International Journal of Design*, Vol. 9, pp, 17–31(2015).
[26] Chung, S., Kramer, T., and Wong, E. M.: Do touch interface users feel more engaged? The impact of input device type on online shoppers' engagement, affect, and purchase decisions. *Psychology and Marketing*, Vol. 35, pp. 795–806(2018).
[27] Shen, H., Zhang, M., and Krishna, A.: Computer interfaces and the "direct-touch" effect: can iPads increase the choice of hedonic food? *Journal of Marketing Research*, Vol. 53, pp. 745–758(2016).
[28] Maddux, W. W., Yang, H., Falk, C., Adam, H., Adair, W., Endo, Y., Carmon, Z., and Heine, S. J.: For whom is parting with possessions more painful? Cultural differences in the endowment effect. *Psychological Science*, Vol. 21, pp. 1910–1917(2010).
[29] Dommer, S. L., and Swaminathan, V.: Explaining the endowment effect through ownership: The role of identity, gender, and self-threat. *Journal of Consumer Research*, Vol. 39, pp. 1034–1050(2013).
[30] Iseki, S., Sasaki, K., and Kitagami, S.: Development of a Japanese version of the psychological ownership scale. *PeerJ*, Vol. 10, e13063(2022).
[31] Kim, J., Fiore, A. M., Lee, H-H.: Influences of online store perception, shopping enjoyment, and shopping involvement on consumer patronage behavior towards an online retailer, *Journal of Retailing and Consumer Services*, Vol. 14, pp. 95-107(2007).
[32] Li, D. and Atkinson, L.: The role of psychological ownership in consumer happiness, *Journal of Consumer Marketing*, Vol. 37, pp. 629-638(2020).
[33] Peck, J., and Childers, T. L.: Individual differences in haptic information processing: the "need for touch" scale. *Journal of Consumer Research*, Vol. 30, pp. 430–442(2003).
[34] Citrin, A. V., Stem, D. E., Spangenberg, E. R., and Clark, M. J.: Consumer need for tactile input. *Journal of Business Research*, Vol. 56, pp. 915–922(2003).
[35] Kühn, F., Lichters, M., and Krey, N.: The touchy issue of produce: need for touch in online grocery retailing. *Journal of Business Research*, Vol. 117, pp. 244–255(2020).
[36] Van Kerrebroeck, H., Willems, K., and Brengman, M.: Touching the void: exploring consumer perspectives on touch-enabling technologies in online retailing. International *Journal of Retail and Distribution Management*, Vol. 45, pp. 892–909(2017).
[37] Mitsuda, T., and Wang, Q.: Preference for objects handled online using virtual touch without haptic feedback. *Transactions of Human Interface Society*, Vol. 24, pp. 315–322(2022).
[38] Jacobsen, L. F., Stancu, V., Wang, Q. J., Aschemann-Witzel, J., and Lähteenmäki, L.: Connecting food consumers to organisations, peers, and technical devices: the potential of interactive communication technology to support consumers' value creation. *Trends in Food Science and Technology*, Vol. 109, pp. 622–631(2021).
[39] Shen, B., Tan, W., Guo, J., Zhao, L., and Qin, P.: How to promote user purchase in metaverse? A systematic literature review on consumer behavior research and virtual commerce application design. *Applied Sciences*, Vol. 11, 11087(2021).

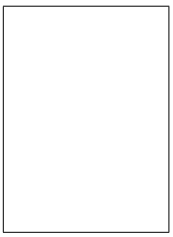
Appendix

The participants answered the following questions.
(1) Psychological ownership
Regarding the selected product,
1 I feel like the product is mine.
2 I feel like I am the owner of this product.
3 I feel like I own this product.
(2) Shopping enjoyment
Please imagine your shopping experience on a website as if you were actually buying foods online.
1 Was it fun (to operate)?
2 Was it interesting (was it a new experience for you)?
(3) Touch sensations
When you evaluated products,
1 Did you feel like you could perceive the texture of the product?
2 Did you feel like you could touch the product?
3 Did you feel like you could move the product as you intended?

(received Jun. 14, 2023, revised Sep. 5)

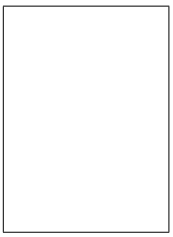
Biography

Takashi Mitsuda



Takashi Mitsuda received the Ph.D. degree in Engineering from Osaka University, Japan, in 1998. He has been a professor of Ritsumeikan University, Japan, since 2008. His research interests include soft robots, haptic displays, preference judgments, and hand-eye coordination.

Xian Zhang



Xian Zhang received the Master's degree in Engineering from Ritsumeikan University, Japan, in 2023.