ABSTRACT This study examines in what way tactile impressions affect consumers’ willingness to pay for a product. We used a sample of 139 students and staff from a large university in Japan. Participants, who are also consumers of smartphone covers, were asked to share their willingness to pay for smartphone covers with four types of surface textures (A, B, C, and D) when the reference smartphone cover price was either 100 yen or 1,000 yen (1000 yen = 7.89 EUR). The smartphone covers were differentiated by surface smoothness, height, slipperiness, dampness, granularity, stickiness, and dryness. The results showed that respondents were willing to pay a premium for most of the textures. Furthermore, our study found that consumers’ willingness to pay for a surface texture depends on demographic and socio-economic features. This study’s results provide preliminary evidence on the value of tactile impressions, providing a foundation for more comprehensive studies in the future.

INDEX TERMS Smartphone cover, surface texture, tactile impressions, willingness to pay.

I. INTRODUCTION Surface texture is an important aspect of product design. Although several studies deal with various types of surface textures and their usefulness, the commercial viability of the surface texture has hardly been empirically examined. Potential consumers’ willingness to pay for surface texture is as important a factor as developing the surface texture. The willingness to pay for a new surface texture is a context-sensitive and consumer-discretion-oriented issue. As consumers’ willingness to pay depends on their perception of the new surface texture, correctly assessing this perception is crucial for a product’s pricing, promotion, and positioning decision. Generally, a product feature that provides consumers additional satisfaction affects their willingness to pay for a product, as confirmed by the literature [1], [2], [3], [4], [5], [6], [7], [8], [9], and [10]. Researchers and strategists also found that adding physical convenience or comfort factors to a product creates additional value [11], [12], [13]. User comfort has many dimensions, ranging from product material to eye-soothing colors, which manufacturers have been adding as product features. While some of these features are expensive to add, others are less expensive and could be value-generating. Tactile impression is one such feature that is less expensive and yet, has the potential to add value.

People determine their preference for products through various sensory perceptions such as visual, auditory, and tactile perceptions. While visual and auditory perceptions are generally common in determining product preferences, people often ignore the effectiveness of tactile considerations in product design [14]. Tactile impression is an important aspect of a product and creates product variation by differentiating...
the surface texture, thereby eliciting different responses from users. Different product textures, some of which are not even visible, provide different surface quality and tactile sensations. Numerous bio-surface studies have focused on product texture and how skin and objects affect haptic and tactile impressions [15], [16]. Previous studies also emphasized the need to develop knowledge geared toward designing surface textures that users like to touch [17] and derive pleasure from [18], improve performance [19], and gain touch-based control [20]. The findings of these scientific studies clearly show that product texture has a definitive role in how consumers respond to a product. Thus, it is important to study how tactile impressions can be utilized for marketing purposes and to generate product value. By not paying attention to a product’s tactile impression, companies ignore the value additive quality of willingness to pay for a product in their pricing strategy. Utilizing tactile impressions, in addition to visual and auditory perception, thus helps to develop a sustainable product pricing strategy.

The smartphone cover is a product whose surface texture and tactile impression demand special attention. Users often face the problem of smartphones that drop or slip from their hands. The problem becomes aggravated for larger smartphones, which have multiple uses that necessitate users to hold them for longer periods. Users also find it convenient if the smartphone cover provides an easy grip and feels pleasant when held. Manufacturers are already concerned about the features that smartphone users seek on the cover, such as multiple positions, sleep-wake functions, screen protectors, and others. Considering the users’ needs, manufacturers provide these features in smartphone covers. Material quality, technological sophistication, eco-friendliness, and functional and physical convenience are already documented as important value-added features [13], [21], [22], [23]. There are studies confirming value creation through the use of color, even in product labels [24]. Reference [25] found that consumers are more persuaded by color highlights in an advertisement compared with an advertisement that is simply black and white. Studies on color have also revealed that the color red leads to perceptions of better performance [26] and that color sometimes becomes a more important determinant in the purchase decision than other attributes [27]. However, a unique feature that is often ignored or not explored deeply is surface texture and related tactile impressions. To the best of our knowledge, there is no study on how consumers value surface textures and tactile impressions to date. This study examines how tactile impressions are related to willingness to pay for a product.

We conducted the study on a sample of 139 students and staff from a large university by observing how participants value the tactile impressions of smartphone covers. There have been many studies on surface texture and tactile impressions from an engineering or scientific perspective. However, studies on the commercial application of tactile impressions for product pricing strategies are lacking. As this is an important issue, tactile impressions should be studied alongside product size, shape, design, and color. The rationale for conducting this study is to provide preliminary evidence on the value of tactile impressions in designing product pricing strategies. As it is difficult to generalize the results of this study due to the limited sample size (the majority of which are students), our evidence will create a pathway for future research, which will explore the issue on a bigger spectrum. Nevertheless, to the best of our knowledge, this is the first study that examines how willingness to pay for a product changes because of different tactile impressions. The results of the study contribute to the literature by providing an understanding of the commercial importance of tactile impressions and how this importance is related to consumers’ demographic, socio-economic, and product-usage-related features. The rest of this article is organized as follows. Section II outlines the data and methodology of the study, Section III summarizes the empirical results, Section IV discusses the results, and Section V concludes.

II. DATA AND METHOD
A. DATA
The experiment on the willingness to pay for tactile impressions was conducted at a large university in Japan from July 4 to July 11, 2019. A total of 139 students and staff from various departments participated in the study. The sampling was conducted in two stages. In the first stage, we circulated an open invitation to the students to participate in a prospective study, the purpose of which was not declared at the time of the announcement. Several students responded to the announcement to participate in the study voluntarily. In the second stage, all prospective participants were briefed about the purpose and procedure thereof, and they agreed to participate in the experiment. We prepared a questionnaire covering the smartphone cover textures and related tactile impressions, as well as the demographic, socio-economic, and usage-related features of smartphone users.

The most important component of the experiment was to measure the willingness to pay for smartphone covers with different tactile impressions without considering shape, function, or color. To measure willingness to pay, our study utilized the contingent valuation method and an open-ended question style that directly asked respondents how much they would be willing to pay for certain types of products [28], [29], [30]. As it is essential to fix a reference point in open-ended questions to measure willingness to pay [28], [31], [32], we used external reference prices, that is, prices from the market [32], [33], [34], [35]. A smartphone cover is a product that is related to people’s daily lives and is easily available to Japanese consumers in 100-yen shops; in 2019, there were more than 6,000 such stores across Japan [36], [37], [38]. In addition, a smartphone cover from a 100-yen shop is considered a good substitute for other smartphone covers in the market, and this should be considered to avoid estimation bias [32].

Our study used both reference product and reference price as the reference point for the respondents. We provided the
participants with a plastic smartphone cover from a 100-yen shop (reference product) together with smartphone covers with four different surface textures, named A, B, C, and D (as shown in Fig. 1 and Fig. 2), each with a different tactile impression. The textures were differentiated by using different types of materials or the same material in varying magnitudes. Particularly, surface textures’ smoothness, height, slipperiness, dampness, granularity, stickiness, and dryness were different from each other. Reference [39] used the same surface textures in their study and identified these points of differences that made the surface textures unique. The parameters of surface roughness used in the experiment are shown in Table 1. The four types of surface textures created different tactile impressions for the respondents.

The figure 1 shows the graphical representation of how participants of this study assessed tactile impressions of smartphone covers with and without surface textures. The reference smartphone cover and the ones with different surface textures were kept in designated boxes. The participants were asked to feel the tactile impression of the smartphone covers and share their willingness to pay for a specific tactile impression, which was compared with the reference smartphone cover without any surface texture. They were asked how much they were willing to pay for each cover with a surface texture if the price of the reference smartphone cover was 100 yen, and again how much they were willing to pay if the price of the reference smartphone cover was 1,000 yen.

In the experiment, the participants were asked to share their willingness to pay for each type of smartphone cover when the reference prices of the smartphone covers were 100 yen and 1,000 yen, respectively. That is, the participants were asked to indicate their willingness to pay for tactile impressions by comparing a smartphone cover with a given surface texture (e.g., type A) with a smartphone cover without surface texture (reference product) when the reference smartphone cover prices were 100 yen and 1,000 yen, respectively. While considering their willingness to pay for tactile impressions, the participants were asked not to consider the shape, function, or color of the smartphone cover. As the smartphone covers in this study were identical, it is less likely that the willingness to pay would be affected by their shapes, functions, or colors. Fig. 3 depicts the experimental setup.

The reason for asking participants’ willingness to pay for tactile impressions against two reference prices was to understand how their assignment of value premium (or discount) changed when the price was higher. Moreover, the upper and lower reference prices accommodated the perceptions of different groups of customers. The upper reference price, 1,000 yen, was used to represent an average high-priced smartphone cover in the market. Conversely, the lower reference price, 100 yen, was used to represent a smartphone cover for regular use. In addition to the willingness to pay for tactile impressions, we also collected information on each respondent’s gender, age, usage and replacement time of smartphones, smartphone type, living status in the household, disposable income, and risk preference. Table 2 shows the definitions and measurement aspects of the variables.

Table 3 shows the descriptive statistics of the variables in this study. Log-transformation was used for the willingness to pay variable to avoid estimation bias due to left-skewed distribution [28], [29], [32]. Therefore, the respondents who stated zero willingness to pay were recoded as 0.0001 after log-transformation. The total number of observations in this study was 139. Results show that 66% of all respondents were male, the average age was 21.32 years (SD = 4.08), the average daily smartphone usage time was 291.01 minutes (SD = 161.32), 65% of respondents were iPhone users, the

| Surface Type | Arithmetic Mean Roughness (Ra) | Maximum Height (Rz) | Average Roughness (Rsm) |
|--------------|--------------------------------|---------------------|------------------------|
| A            | 0.07                           | 0.82                | 129                    |
| B            | 1.69                           | 9.53                | 99                     |
| C            | 0.65                           | 4.45                | 162                    |
| D            | 1.06                           | 10.63               | 179                    |
average number of months for which the current smartphone was used was 22.24 months (SD = 15.30), average replacement time of the smartphone was 32.36 months (SD = 11.95), 87% of the respondents lived alone, and average monthly income was 43,000 yen (SD = 25,600). We also evaluated respondents’ perceptions of uncertainty from the question, “Usually, when you go out, how high does the probability of rain have to be before you take an umbrella?” Respondents showed a moderate degree of uncertainty avoidance; they would take an umbrella if there were a 55% probability of rain.

B. METHOD
The dependent variable in this study was the log of willingness to pay. As the values of the log of willingness to pay were always higher than zero, a Tobit regression was suitable to provide unbiased and consistent results [40], [41], [42], [43]. However, there was a possibility of correlations between dependent variables because the respondents had to state their willingness to pay for four types of smartphone covers with reference prices of 100 yen and 1,000 yen in the same experiment. In other words, the respondents made joint decisions when stating their willingness to pay, and this issue should be taken into account to increase the efficiency of the estimation [32]. Therefore, we employed a multivariate Tobit (mvtobit) technique that allowed for correlation between dependent variables across multiple equations in this study [40], [41], [42],[43]. The likelihood ratio (LR) test in the last row of Table 4 shows that the null hypothesis, which states that error terms are not correlated, is rejected, indicating that the willingness to pay for the four types of smartphone covers is correlated and the use of a multivariate Tobit model in this study is justified. In total, we had eight equations based on eight dependent variables (log of willingness to pay from four types of surface textures [A, B, C, and D] on two reference prices [100 yen and 1,000 yen] for smartphone covers). In all equations, respondents’ gender, age, smartphone usage time (usage), smartphone type (iPhone), period of using the current smartphone (device), expected replacement time of the smartphone (replace), household living status (livealone), disposable income (dincome), and risk preference (rpreference) were used as explanatory variables. These eight equations were jointly estimated by multivariate Tobit regression.

The regression equation is as follows:

$$\log(\text{ap100}), \log(\text{ap1000}), \log(\text{bp100}), \log(\text{bp1000}), \log(\text{cp100}), \log(\text{cp1000}), \log(\text{dp100}), \log(\text{dp1000})$$

$$= \beta_0 + \beta_1 \text{gender} + \beta_2 \text{age} + \beta_3 \text{usage} + \beta_4 \text{iPhone} + \beta_5 \text{device} + \beta_6 \text{replace} + \beta_7 \text{livealone} + \beta_8 \text{dincome} + \beta_9 \text{rpreference} + \epsilon_i.$$  

III. EMPIRICAL RESULTS
A. WILLINGNESS TO PAY
The descriptive statistics in Table 3 indicate that the respondents were willing to pay a premium for smartphone covers in most cases. For a smartphone cover with an A-type surface
texture, the respondents were willing to pay an average price of 140.48 yen ($SD = 172.44$) when the reference price was 100 yen. Thus, they were willing to pay an average premium of 40.48 yen for the A-type surface texture when the reference price was 200 yen. For the C-type smartphone cover, the respondents were willing to pay an average price of 221.65 yen ($SD = 246.96$) when the reference price was 100 yen. Similarly, for the same smartphone cover, the respondents were willing to pay an average price of 1,223.89 yen ($SD = 475.63$) when the reference price was 1,000 yen and 1,000 yen (i.e., an average premium of 233.89 yen).

For a smartphone cover with a C-type surface texture, the respondents were willing to pay an average price of 256.09 yen ($SD = 294.65$) when the reference price was 100 yen (i.e., an average premium of 156.09 yen). For the same smartphone cover, they were willing to pay an average price of 1,510.47 yen ($SD = 1,347.35$) when the reference price was 1,000 yen (i.e., an average premium of 510.47 yen).

For a smartphone cover with a D-type surface texture, when the reference price was 100 yen, the respondents were willing to pay an average price of 209.17 yen ($SD = 228.48$), that is, an average premium of 109.17 yen. For the same smartphone cover, when the reference price was 1,000 yen, they were willing to pay an average price of 1,190.29 yen ($SD = 503.57$), that is, an average premium of 190.29 yen.

The results show that the respondents were willing to pay a premium for all types of smartphone covers, except for the A-type surface texture when the reference price was 1,000 yen. The descriptive statistics show a wide dispersion of the prices that the respondents were willing to pay for smartphone covers with different surface textures. The respondents were willing to pay the maximum premium for the tactile impressions of the C-type smartphone cover when the reference price was 100 yen. It is also remarkable that the maximum prices that the respondents were willing to pay for tactile impressions when the reference prices were 100 yen and 1,000 yen were as high as 2,000 yen and 12,000 yen, respectively. The respondents were willing to pay as low as 0 yen for all types of smartphone covers, except for the C-type surface texture.

### B. REGRESSION RESULTS

Table 4 shows the multivariate Tobit regression results of how respondents’ willingness to pay for tactile impressions is related to gender, age, smartphone usage time (usage), type of smartphone (device), period of using the current smartphone (replace), household living status (livealone), disposable income (dincome), and risk preference (rpreference).

For the A- and B-type smartphone covers, the regression coefficients in columns 1 to 4 show that no variable was significantly related to the respondents’ willingness to pay for a smartphone cover, regardless of whether the reference prices were high or low. For the C-type smartphone cover, the regression coefficients in column 5 (log [cp100]) show that age, smartphone usage time (usage), and household living status (livealone) had significant positive relationships with the respondents’ willingness to pay for a smartphone cover when the reference price was 100 yen. These results indicate that the older respondents used smartphones for a significant amount of time, and those who lived alone tended to value the C-type smartphone cover more than others when the reference price was 100 yen. The regression coefficients in column 6 (log [cp1000]) show that household living status (livealone) and risk preference (rpreference) had significant positive relationships with the respondents’ willingness to pay for a smartphone cover when the reference price was 1,000 yen. These results indicate that the respondents who lived alone and the risk-taking respondents tended to value C-type smartphone covers more than their counterparts when the reference price was 1,000 yen.

For the D-type smartphone cover, the regression coefficients in column 7 (log [dp100]) show that the phone replacement period (replace) had a significant negative relationship with the respondents’ willingness to pay for a smartphone cover when the reference price was 100 yen, indicating that the respondents who had a longer expected replacement time of the smartphone tended to value the D-type surface texture less than the respondents who had a shorter expected replacement time. The regression coefficients in column 8 (log [dp1000]) show that risk preference (rpreference) had a significant positive relationship with respondents’ willingness to pay for a smartphone cover when the reference price was 1,000 yen. This result indicates that risk-taking respondents tended to value D-type smartphone covers more than their counterparts when the reference price was 1,000 yen.

### IV. DISCUSSION

Tactile impressions are an important factor in product design and have received significant consideration in engineering and scientific studies. Previous studies have confirmed that different surface textures create variations in tactile impressions through the superficial sensory nerves on the fingers [14], [44], [45], [46]. Thus, it is highly possible that variations in tactile impressions would create different feelings for any product and could affect its price. However, to the best of our knowledge, no study has examined the commercial application of tactile impressions or how tactile impressions can be used for value creation. Therefore, we conducted this study to fill this gap. Our study examines whether tactile impressions are an important factor in consumers’ willingness to pay for a product. The results provide evidence of the
importance of tactile impressions in the price determination of smartphone covers.

The descriptive statistics suggest that the respondents were generally willing to pay a premium for tactile impressions,
regardless of the reference prices. However, for the A-type surface texture, the respondents were unwilling to pay a premium when the reference price was 1,000 yen; instead, they expected a discount. Other than that, the respondents were willing to pay a premium for the other types of surface textures for both reference prices. The average premium they were willing to pay ranged from as low as 19.03% to as high as 156.08% of the reference price. Our results suggest that tactile impressions offer specific advantages to users for which users are willing to pay premiums. Our findings are consistent with previous studies showing that consumers are increasingly placing more importance on additional qualities of a product other than performance, tactile impression being one of those [47], [48], and [49]. Orsini and Kalbaska [50] and Pino et al. [51] also found the importance of tactile impressions creating a positive attitude towards products. Tactile impression not only provides a better subjective feeling of grasping a product, but also provides some tangible benefits. In summary, this result supports our assumption that tactile impressions, through variations in product surface texture, have an impact on price.

To understand the price impact of tactile impressions, we used multivariate Tobit regression models to relate respondents’ willingness to pay with gender, age, smartphone usage time, type of smartphone, period of using the current smartphone, expected replacement time of the smartphone, household living status, disposable income, and risk preference. The LR test indicates that the willingness to pay for all types of smartphone covers was correlated, and the use of the multivariate Tobit model in this study was justified.

The regression results show that no variable was related to the respondents’ willingness to pay for A- and B-type surface textures. Although participants were willing to pay premiums for A and B-type surface textures (except for the A-type surface texture when the reference price was 1000), our results show no specific associations with the background of the respondents. However, age and smartphone usage time had significant positive relationships with the respondents’ willingness to pay for the C-type surface texture when the reference price of the smartphone cover was 100 yen, indicating that the older the age or, the higher the usage time, the higher was the price the respondents were willing to pay for the tactile impression. The sensitivity of age and smartphone usage time were not evident when the reference price was higher. Neither relationship was evident for the rest of the surface textures with any reference prices.

The expected replacement time of the smartphone was found to have a significant negative relationship with the respondents’ willingness to pay for D-type surface texture when the reference price of the smartphone cover was 100 yen, indicating that respondents who had a longer expected replacement time of the smartphone valued the D-type surface texture less than others. The sensitivity of the expected replacement time of the smartphone was not evident when the reference price was higher.

Next, the results of our study provide evidence that the respondents’ household living status had a significant positive relationship with their willingness to pay for C-type surface textures when the reference prices of the smartphone cover were 100 yen and 1,000 yen. These results imply that the respondents who lived alone tended to value the C-type surface texture more than others, regardless of whether the reference prices were high or low. It is imperative that participants who live alone are more likely to be frequent users of smartphones for which the C-type surface texture possibly provides some unique benefits.

Finally, the respondents’ risk preference had a significant positive relationship with their willingness to pay for C- and D-type surface textures when the reference price of the smartphone cover was 1,000 yen, indicating that the risk-taking respondents tended to value the C- and D-type surface textures more than the risk-averse respondents. The sensitivity of the risk preference was not evident when the reference price was lower.

The results suggest that the respondents’ background and risk preferences had value implications for tactile impressions. Although tactile impressions generally provide value-added advantages, they can become an important value-creation criterion by combining specific types of surface textures with reference smartphone covers. Our results show that the C-type surface texture had the most, and the D-type surface texture had some relationship with respondent-related features. The results further imply that the sensitivity of the factors that explain respondents’ willingness to pay for tactile impressions depends on the reference price. Thus, the types of surface textures, respondents’ background, and reference price together determine respondents’ willingness to pay for tactile impressions.

V. CONCLUSION

Tactile impressions are an important aspect of a product that allows the creation of variations by differentiating surface textures, thereby evoking different responses in respondents. Although there have been studies on the development and usefulness of surface textures, no study has examined how tactile impressions created through various surface textures could be related to the value of a product. This study examined how tactile impressions are related to the willingness to pay for smartphone covers. We conducted the study using a sample of 139 students and staff from a large university in Japan. The results showed that the respondents were generally willing to pay higher prices for tactile impressions. The magnitude of the premium was found to be higher when the reference price was low. The regression results showed that the respondents who lived alone tended to value the C-type surface texture more than others, regardless of whether the reference prices were high or low. Moreover, respondents’ age, smartphone usage time, expected replacement time of the smartphone, and risk preferences were also related to some types of tactile impressions.
Our results provide preliminary evidence for the importance and potential value of tactile impressions. We believe this study can serve as a foundation for more comprehensive studies in the future that could produce generalized findings for manufacturers on the significance of including tactile impressions in designing and pricing their products to gain a competitive edge. Manufacturers of electronic gadgets, laptops, wallets, furniture, and others could use user-friendly surface textures to increase the value of the products. If a company understands consumers’ preferences for surface textures and whether they are willing to pay a premium for a product before negotiations, it can develop a better pricing strategy. Evidence on the relevance of willingness to pay for a tactile impression can help to organize the experiment. The authors have no conflicts of interest to declare.

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