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The influence of tactile information on the human evaluation of tactile properties

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Abstract

Virtual technologies such as haptic devices and virtual try-ons have been developed to bring more certainty to the non-touch shopping experience; however, they are still no substitute for the in-person experience. In order to resolve the current limitations of haptic technology, it is necessary to carry out fundamental research on the ways in which humans perceive and discern different tactile properties. This study investigated how vision and physical touch affect the evaluation of the tactile properties of knitwear and discovered factors that affect tactile evaluation in a non-touch environment. The result of this study proved that humans can perceive tactile properties similarly when they are able to physically touch the fabric, whether their vision is obstructed or not. However, participants were unable to accurately perceive the tactile properties of knitwear when they evaluated fabrics using only visual materials, especially stretchiness and flexibility. It is confirmed that a surface haptic experience could increase the accuracy of stretchiness and flexibility evaluations, but it did not help in the evaluations of fabric thickness and heaviness. Findings from interviews suggested that the shape, width and number of folds, density, and thickness of the yarn are all major factors that influence the tactile perception of knitwear when participants could only evaluate properties through on-screen visual materials. Findings from this study contributes to the improvement of the consumer experience in the contact-free shopping environment and can be used as a fundamental guide to human perception of clothing, which can support technologies such as haptic devices.

Keywords: Haptic information, Tactile perception, Touch, Visual-tactile interplay

Introduction

The recent pandemic crisis has caused the largest increase in online shopping to date as physical distancing is being encouraged worldwide. According to a report from Mckinsey, online apparel sales have increased by nearly ten percent since the beginning of the pandemic, and that trend is expected to continue for the long term (Briedis 2020). The current situation is making touch-free shopping a necessity. The largest barrier in online apparel shopping is the inability to physically inspect the fashion items. Compared to other product categories, such as household goods, touch is extremely important in purchasing apparel. When consumers shop apparel online, they can only imagine how the fabric might feel against the skin and judge the quality and aesthetic value of the product through mobile, tablet, or computer screen. Unfortunately, this results in a high return rate of 40% for online apparel sales, which prompts online shopping sites to try and provide as much specific product information as possible along with enlarged photos and videos (Ji 2009). In addition to product visuals, virtual technologies such as haptic devices and virtual try-ons have been developed in an attempt to bring more certainty to the non-touch shopping experience; however, they are still no substitute for the in-person experience. Previous studies have suggested that there remains a huge gap between the tactile properties perceived from a haptic device and by actual human hands (Chen et al. 2015). As a result, there is a need for fundamental research on the ways in which humans perceive and discern different tactile properties.

In order to resolve the current limitations of haptic technology, it is necessary to understand a wide range of related sensations and perceptions. Fashion-related haptic research has been focused on transmitting objective tactile information gained through mechanical measurement, such as the Kawabata Evaluation System, onto textiles. Subjective and affective evaluation has not previously been considered as important as the objective evaluation. However, in recent years, researchers argued that the mechanically measured tactile properties are not equivalent to the tactile perceptions of touching the fabric with human hands, which underscores the importance for subjective and affective assessment (Chen et al. 2015). It has been suggested that the haptic experience should combine the visual and tactile senses, which requires an integrated study on touch and vision (Xiao et al. 2016). Prior research has concluded that vision and touch are equally important factors in the human evaluation of a product that influence the purchase decision (Jansson-Boyd 2011). Xue et al. (2016) explored the relations between the visual and haptic perceptions of tactile properties and concluded that most fabric tactile properties could be well perceived through vision without actual touch. The authors insisted when we saw and touched an object, the tactile information gained from the multisensory experience was accumulated in our brain and seeing visual representations of the object could evoke the memory. Thus, visual materials were sufficient to deliver tactile properties when touch was deprived but the accuracy depends on the level of the stored memories. On the other hand, Peck and Childers (2003) concluded that physical touch was irreplaceable especially for certain type of people. They examined the effects of haptic information when physical touch was unavailable and analyzed data based on how consumers' level of needs for touch was associated. The results indicated that a picture of the product with an important haptic written description increased confidence in judgment for less haptically motivated consumers (low-NFT). However, a high-resolution color picture or three-dimensional representation would result in elevated frustration for more highly haptically motivated consumers (high-NFT) because the visual materials could not resolve a longing for the direct experience of product through physical touch. With these conflicting research studies, the usefulness of a detailed visual representation still appears to be undetermined.

This study proposes evaluating the dynamics between visual and tactile inputs in various contexts to understand the complexity of human perception when evaluating apparel. It seeks to understand how vision and physical touch can affect the evaluation of tactile properties of apparel and identify factors that might affect tactile evaluation. A series of experiments were designed to test human perceptions of tactile properties in varying conditions. In order to focus on the human perception rather than the textile itself, a controlled fabric type was selected. Prior to the study, a preliminary investigation was conducted to identify types of appeal that are difficult to purchase online. Twelve fashion industry experts who have master's degrees in clothing and textiles were surveyed, and eleven of those twelve experts agreed that knitwear was the hardest to buy online. Therefore, this study focuses specifically on knitwear. Findings from this study will contribute to the improvement of the consumer experience in the contact-free shopping environment and can be used as a fundamental guide to human perception of clothing, which can support technologies such as haptic devices, VR, and AR shopping.

Methods

Objectives and hypotheses

This study explores how vision and touch affect the evaluation of tactile properties and determines factors that might specifically affect the tactile perception of knitwear. It also seeks to identify the influence of the different types of tactile information provided for the human tactile analysis. Three research objectives and hypotheses were outlined for this study.

(1) To identify the relationship between vision and touch as it pertains to tactile evaluation.

H1 Humans will develop different perceptions when touching the fabrics without seeing them compared to touching and viewing the fabrics.

(2) To describe the effect of on-screen visual materials on the tactile evaluationof knitwear

H2 Tactile properties of knitwear cannot be accurately conveyed through digital photos and videos.

(3) To confirm the influence of a surface haptic experience on tactile evaluation when it is provided along with visual materials.

H3 A limited haptic experience of the material's surface will not increase the accuracy of the tactile evaluation.

To fully understand the complexity of human perception while evaluating fabrics, mixed methods integrating both qualitative and quantitative methods were incorporated. The study was conducted in three steps. The first step was a pre-questionnaire that confirmed participants' familiarity with knitwear and interest in fashion. In step two, four experiments were conducted in varying conditions to identify how different types of tactile experiences can affect human perceptions. The final step consisted of an interview that sought to understand physical, physiological, and psychological factors that influenced the perception of fabrics.

Material and preparation

To focus solely on human perception, all fabric samples are precisely controlled. Six types of knitted fabric samples, created exclusively for this study, were made with the same quality using 100% Merino grey wool yarn. An electronic knitting machine was set to create three levels of different thickness (gauge 3, 7, and 12) in the lowest and highest density. The six knitted samples were created into two forms each: swatches and sweaters. All 12 samples (six swatches and six sweaters) were labeled intentionally with randomly assigned numbers. The size of the swatches and sweaters used for the evaluation were 20 × 20 cm and a women's medium, respectively. The sweaters were designed in a basic, long-sleeved crewneck style and no labels were attached.

To create the visual representations, a 30-year-old woman with an average size body shape was invited to serve as a mannequin. A series of photos and videos were taken using the same lighting and location for each sample. A front, side, three-quarter, and back view of the model wearing the sweater were photographed. For the video clips, the model was asked to slowly rotate for ten seconds to show a 360° view of the sweater. The photos and videos were displayed on a 15″ retina screen laptop adjusted to maximum brightness and textual descriptions were not provided (Fig. 1).

All samples were placed on a clean, white table, and participants were asked to cleanse their hands with wet tissues prior to touching the samples. They were not permitted to put any moisturizing lotion onto their hands afterwards that might affect the feeling perception. The experiments were conducted in a room with a controlled temperature of 25–26 °C.

Participants

For this study, a total of 28 women between the ages of 20 and 40 were selected as participants. Women tend to have better finger sensitivity than men, and older participants would likely have lower finger sensitivity than younger ones (Musa et al. 2019). The main inclusion criterion was a high tactile sensitivity. Following the completion of the pre-questionnaire, seven people were excluded due to their lack of familiarity with knitwear. As a result, only 21 subjects participated in the experiments. The participants were undergraduate students, post-graduate students, and researchers in the department of clothing and textiles. This research is approved from SNU IRB for the experiments. The approval number is IRB No. 1909/001-005.

Fig. 1 Visual materials provided on screen

Experiments

Seven individuals were randomly assigned to four separate experiments for this study. Because seven individuals were excluded by the pre-questionnaire, seven of the 21 participants participated in two experiments. After finishing the first experiment, they were asked to come back four weeks later to take part in another experiment. The numbers assigned to each sample were reassigned following the first experiment to avoid participants' memory impacting the second evaluation.

Figure 2 displays an overview of the four experiments. In the first experiment, Participants were asked to detect the features of sweaters based on their perceptions of images and videos on screen, which they were welcome review and replay in detail as many times as they desired. For this study, textual descriptions such as composition of the fabric and label were intentionally removed to focus on the human perception of fabric texture itself.

The same visual materials from the first experiment were used for the second experiment, but a real touch experience with the surface of swatches was added. Each swatch was placed in a box so that participants could not see them. While reviewing the visual materials on screen, participants were asked to examine the fabric swatch using their fingertips, but were not allowed to grasp or stretch the material. During the experiment, a research assistant guided participants to touch the specific swatch sample that matched the visuals they were seeing on the screen.

The third experiment required participants to evaluate the sweaters by physically touching them without restriction. Each participant was allowed to see the sweaters and play with them. The final experiment was similar to the third experiment; however, participants were blindfolded. They were asked to touch the sweaters while wearing black eye patches.

Evaluation and interview

Participants evaluated the six samples in the context of one of four experiments. A tactile evaluation sheet was developed and consisted of four components: heaviness,

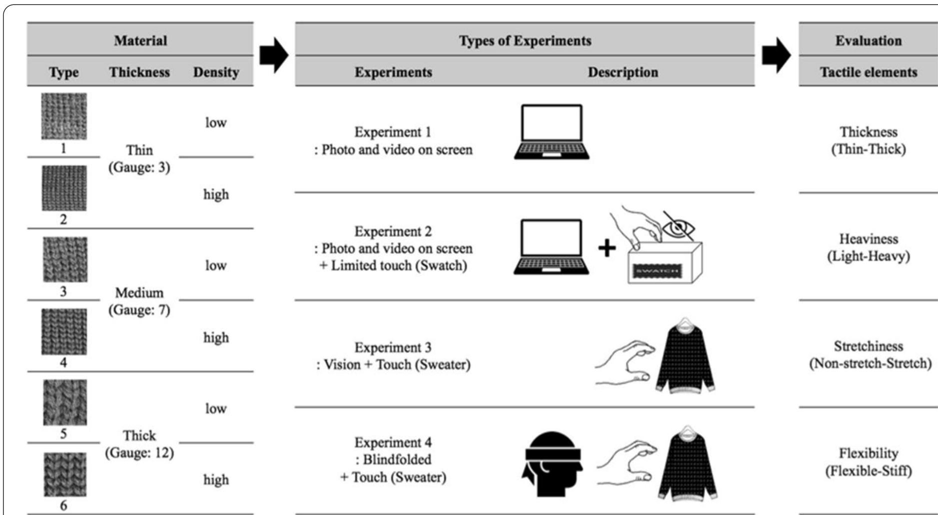

Fig. 2 Overview of the experiments

thickness, stretchiness, and stiffness. A six-point scale was used for each component, with 1 representing light, thin, non-stretch, and flexible, and 6 representing heavy, thick, stretchy, and stiff, respectively. Prior to the experiments, a pre-test was conducted to four participants using 10-point scale and all participants expressed difficulties in rating. They mentioned that as differences between each fabric samples were subtle, 10-point scale was too wide. We tested 5, 6, 7 point scale to identify the proper range and participants responded that 6-point scale was appropriate.

Prior research on human hand evaluation of fabrics suggested that a rating method provides the most advantages when the number of fabrics is limited to 10 or fewer, since the ratings can relay more information such as the rank of the samples or the degrees of differences between them (Musa et al. 2019). The results of each experiment in this study were analyzed using SPSS 25.0 to determine any relationship between each experiment. Despite the small sample size, paired t-tests were utilized as in previous studies (Xiao et al. 2016; Yanagisawa & Takatsuji 2015). Some results demonstrated zero standard deviation due to identical ratings, which presented a limitation for this study. A non-parametric test (Wilcoxon signed rank test) was also conducted to verify if there was any difference between results. No statistically significant differences were discovered for either method, so the results of the paired *t* tests were provided in this paper.

Participants' behavior was observed during the evaluation process, and participants were interviewed for ~ 30 min following the experiment to ask them to identify specific factors they considered during their evaluation process. Characteristics of participants' behavior during the evaluation process were recorded on an observation sheet, and interviews were recorded and transcribed. For the fourth experiment where participants were blindfolded, participants verbally expressed their evaluations and a researcher recorded the rating on their behalf.

Result

Vision and touch

H1 Humans will develop different perceptions when touching the fabrics without seeing them compared to touching and viewing the fabrics.

To examine the relationship between vision and touch, two experiments were conducted within different contexts. The third experiment allowed participants to physically see and touch the sweaters while the fourth experiment invited participants to touch the sweaters while blindfolded. A paired t-test was conducted on the results of experiment 3 and 4. Table 1 shows no significant relationship between the results of experiments 3 and 4 (p-value > 0.05). Regardless of the type of knitted fabric, there was no statistically significant difference.

As a result, the data appears to reject the premise of the first hypothesis. Despite being blindfolded, participants were able to perceive the tactile properties of knitwear as well as they did without a blindfold. These findings demonstrate the strong influencing power of physical touch as people evaluate fabrics. Regardless of vision, physical touch is the more important sense when evaluating tactile properties.

Table 1 Results for paired t-test analysis showing p-values

Sample	Sweater			
	Experiment 3 (vision + touch) and 4 (touch)			
	Heaviness	Thickness	Stretchiness	Flexibility
1	N/A	N/A	0.68	0.34
2	0.75	0.55	0.10	0.56
3	1.00	0.35	1.00	0.15
4	0.54	0.29	0.22	0.50
5	0.17	1.00	0.33	0.24
6	0.36	0.36	0.13	1.00

N/A = the standard deviation of the experiments is 0, showing identical rating results

Visual representations

H2 Tactile properties of knitwear cannot be accurately conveyed through digital photos and videos.

This hypothesis was examined in experiments one and three using a paired t-test (Table 2). In the third experiment, people can physically see and touch the sweaters freely. Conversely, the first experiment only offered visuals of the six sweaters for participants to evaluate on screen. As a result, statistically significant differences were identified in certain components of sample evaluations between both experiments: sample four in the evaluation of heaviness (p-value = 0.04) and sample four in the thickness evaluation (p-value = 0.03).

Further differences were identified in the evaluation of stretchiness and flexibility, which participants stated was the most difficult component to evaluate on screen. Among the six samples, samples two and five showed differences. Participants pinpointed sample two (p-value = 0.02), which is thin but dense, and sample five (p-value = 0.04), which is thick but loose, as the hardest samples to evaluate the actual feeling of the fabric. The same samples [sample two (p-value = 0), sample five (p-value = 0.02)] were the hardest samples to evaluate on the basis of stretchiness.

The results demonstrate that it is difficult to perceive the tactile properties of the fabric solely by reviewing them on screen, even if videos are also provided. Stretchiness and

Table 2 Results for paired t-test analysis showing p-values

Sample	Visual materials only				Visual materials + surface haptic experience			
	Experiment 1 and 3 (H2)				Experiment 2 and 3 (H3)			
	Heaviness	Thickness	Stretchiness	Flexibility	Heaviness	Thickness	Stretchiness	Flexibility
1	0.35	N/A	0.50	0.27	0.14	N/A	0.73	0.44
2	0.23	0.27	0.02*	0.00*	1.00	0.02*	0.71	0.73
3	1.00	0.76	0.07	0.30	0.01*	0.10	0.05	0.59
4	0.22	0.03*	0.09	0.82	0.07	0.03*	0.45	0.73
5	0.04*	0.66	0.04*	0.02*	0.81	0.27	0.35	0.51
6	0.27	0.22	0.87	0.82	0.35	0.35	1.00	1.00

*Significant difference between experiments, p-value < 0.05

N/A = the standard deviation of the experiments is 0, showing identical rating results flexibility in particular are the hardest properties to discern through a computer screen without physical touch.

Haptic experience

H3 A limited haptic experience of the material's surface will not increase the accuracy of the tactile evaluation.

In addition to the experiments used to evaluate the second hypothesis, another experiment was conducted to specifically determine if a surface haptic experience could reduce the uncertainty of perceiving fabric properties. Surface haptic devices are designed to help people evaluate the texture of fabric through a pad when they cannot physically touch the fabric. The second and third experiments were analyzed in a paired t-test (Table 2), and these results were compared to the results of the first experiment, which were obtained when testing the second hypothesis, to identify if a surface haptic experience can increase the accuracy of tactile perception.

The results indicated no significant differences between (p-value > 0.05) the evaluations of stretchiness and flexibility. The data show that a surface haptic experience can reduce the uncertainty in evaluating samples two and five, which were considered by participants as the most difficult fabrics to evaluate using only visual materials. However, significant differences were discovered in the heaviness of sample three (p-value = 0.01), and the thickness of samples two (p-value = 0.02) and five (p-value = 0.03). This result indicates that the surface haptic experience is helpful in evaluating the stretchiness and flexibility of fabrics, but it cannot assist people in evaluating the heaviness and thickness of fabrics.

Figures 3 and 4 display a comparison of the average scores on the evaluation of stretchiness and flexibility, respectively. The third experiment provides a reference value that shows the results from an actual haptic experience while also allowing participants to physically see and touch the sweaters. The figures confirm the difficulty in discerning the stretchiness and flexibility of the product using only visual materials on screen (experiment one). However, a surface haptic experience (experiment 2) can considerably increase the accuracy.

Qualitative data analysis

All participants were interviewed following the experiments. Interviews were recorded and transcribed verbatim. Iterative-inductive analysis of qualitative data involving open coding was conducted. First, the data were categories by the type of experiments. Examples of categories included tactile cues on screen (E1), tactile cues on a swatch with visual materials (E2), tactile cues in real touch experience of sweater (E3), and tactile cues when blindfolded (E4). In each category, data were divided in to 4 subtopics: thickness, heaviness, stretchiness, and flexibility. During the process of open coding, data were broken down in to pieces to discover relations, similarities, and differences. Then, axial coding was conducted to recombine the subcategories by its characteristics. Finally, selective coding was adopted to develop core categories and new concepts. To ensure the trustworthiness of this study, the authors and an expert who had PhD degree in clothing and textiles were involved in the entire process of coding. These three coders checked the application of coding to the data. To confirm the consistency between coders, the

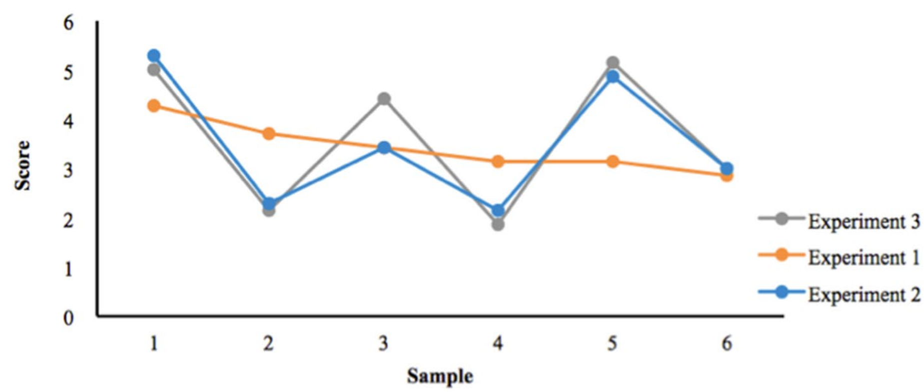

Fig. 3 The comparison of average scores on stretchiness

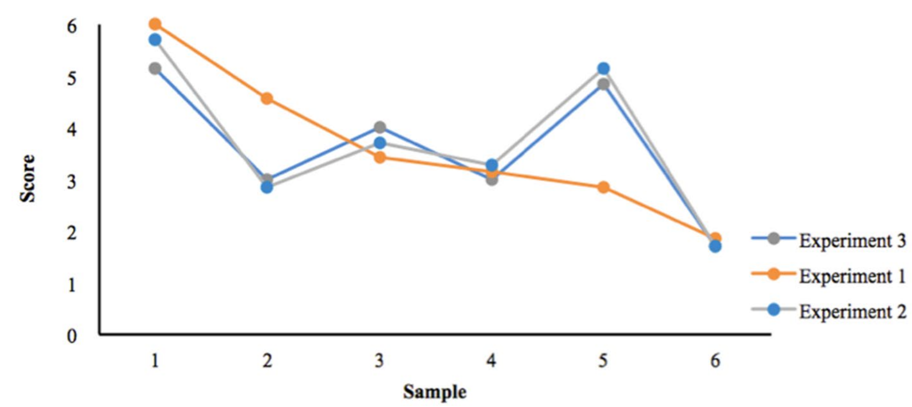

Fig. 4 The comparison of average scores on flexibility

inter-rater reliability was calculated and the result was 97.2%. Microsoft Word and Excel were used to code and determine inter-rater reliability without the use of programmed coding software.

Findings from the interviews

All participants were interviewed following the experiments. In experiment 3 and 4, intuitive responses were found from participants. As participants were able to actually see and touch the sweater by hand in Experiment 3, there was no interesting finding from the interview. The power of touch was confirmed from the comparison of experiment 3 and 4. Although participants were blindfolded in experiment 4, participants felt very comfortable evaluating the tactile properties. It indicated that people could perceive tactile properties well when they were allowed to touch the product freely despite the absence of vision. Some interesting insights were determined from the interviews of participants in the first and second experiments where they were evaluating fabrics using visual materials on screen. Those insights are described below.

Evaluation of thickness and heaviness

The thickness of the yarn influenced the participants' perception of heaviness. If the yarn appeared to be thick visually, participants assumed that it would be heavy. Conversely, if the yarn appeared to be thin, participants assumed it would be a light fabric.

> *I think heaviness and thickness go together. Since it is hard to feel the weight through the screen, naturally I look for thickness to evaluate heaviness (Participant 2).*

Participants also agreed that the density of fabric affects perception if the thickness appears similar. The density of fabric is related to the opacity of sweaters displayed on the body. If the fabric is loose enough to determine the shape of the body through the clothes, it is considered thin and light. On the other hand, if the fabric has a high density that cannot be seen through, it is considered to be thick and heavy.

In addition to the density, the number of folds is also an important factor for the evaluation of heaviness and thickness. Participants commonly identified the shape, width, and number of folds as clues. As the model rotates in the video, the movement and folding of the fabric help in evaluating heaviness and thickness. If the fabric does not fold, it is considered heavy and thick. In contrast, if multiple folds are created as the model rotates, the fabric is considered light and thin. Large, wide folds are associated with thick and heavy fabric, whereas small, narrow folds are associated with thin and light fabric.

Participants also examined the edge of the clothing to determine thickness. If the edge of the sweater appears to be flat against the skin, the fabric is more likely to be considered thin.

Evaluation of stretchiness

The evaluation of stretchiness on screen depends on the density of the knitted fabric. If the fabric appears to be tightly knitted so you can't see through it, it looks stiffer. Regardless of the same yarn being utilized, knitwear appears more stretchy when it is loose-knitted and you can see through it.

A participant highlighted that fabric memory can affect the perception of the sweater, especially when they have to evaluate through visual materials on screen.

> *...If I have experienced similar types of knitwear and I have a memory that it stretched well, it affects the evaluation. The previous memory makes me think that it can be stretched well, even if it does not look so (Participant 6).*

Participants expressed difficulty in feeling stretchiness through visual materials in a non-touch environment. They just assumed that the sweater was stretchy if the fabric looks light and thin on screen. On the other hand, it was considered as non-stretch if it looks heavy and thick,

Folds were an important factor in the determination of heaviness and thickness as well. Participants agreed that if there are many narrow folds diagonally, the fabric would have more stretch. On the other hand, when there are no folds, the fabric is considered to be stiff.

Evaluation of flexibility

Participants commonly agreed that flexibility was related to the thickness and density of the fabric. If the fabric appeared to be thin, loose-knitted, and transparent, it is considered to be flexible. On the other hand, if the yarn is thick and the density of the fabric is high, it is considered to be stiff.

> *…Flexibility was the hardest part to evaluate. I think photos can't deliver the feeling. Only videos can give a hint. How the clothes on the body behaves is the clue (Participant 4).*

The thickness around the edge of the clothing as well as the shape, width, and number of folds are clues to help evaluate fabric flexibility. If there are many folds, the fabric is likely to be more flexible. Additionally, when the fabric appears light and thin, it is considered to be soft and flexible.

Discussion

Participants' behaviors were observed during the evaluation process. Participants tended to watch the videos when they were evaluating stretchiness and flexibility. This suggests that properties like thickness and heaviness are more easily captured through photos, but people need additional materials, like videos, to evaluate stretchiness and flexibility. This is reaffirmed by the participants, who agreed that the hardest properties to evaluate with visual materials only were stretchiness and flexibility. Thickness was relatively considered as the easiest component to evaluate among the four tactile properties. Heaviness was also difficult to perceive through a screen, but participants identified that they could predict the weight of the fabric from its thickness. Overall, the results indicated that various factors such as shape, width and number of folds, density (transparency), thickness, and previous memory ampersands can affect the tactile perception of knitted fabrics (Fig. 5).

Gibson (1962) argued that active touch is not just a sensation felt on the surface of the skin; it is a complex feeling comprised from different parts of the body such as the brain, nerves, and muscles. People have a pre-understanding, memory, or expectation of a product that influences the expected perception of congruence between visual and tactile cues (Eklund and Helmefalk 2018). The haptic system is defined as sensorial, motor, and cognitive mechanics of the nervous system, which connect the brain to the hand (Rodrigues et al. 2017). A tactile perception is associated with vision, touch, and memory, as evidenced by this study. It is a dynamic sensation gained through the eyes, hands, and brain.

We cannot alter a consumer's memory from previous experiences. However, precise visual materials can be provided to help people accurately evaluate tactile properties on screen. Based on the findings of this study, it is recommended that a close-up image of the rib area (Fig. 6) is provided to help consumers determine the thickness of the fabric.

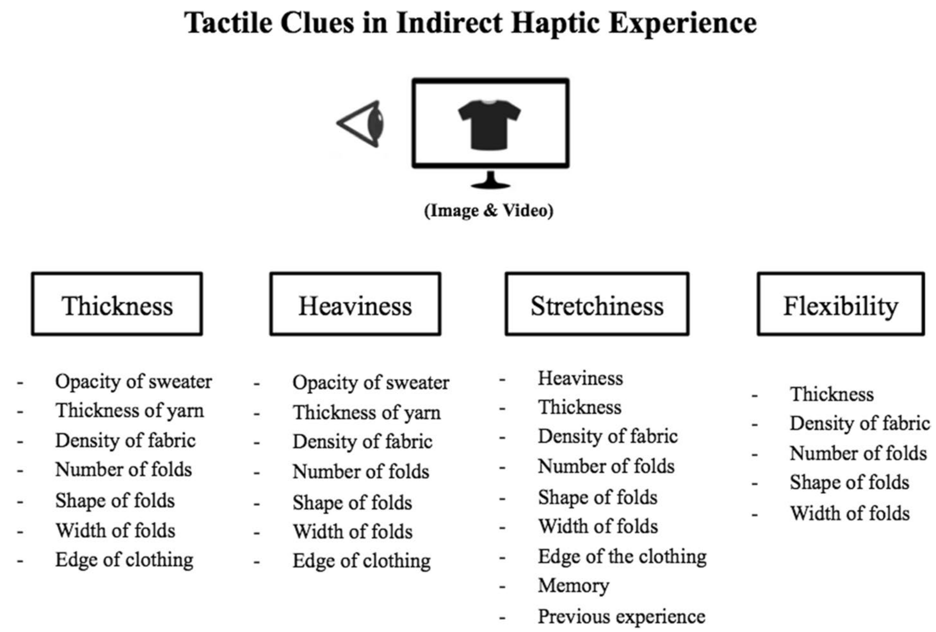

Fig. 5 Tactile clues identified from interviews of experiment 1 and 2

Fig. 6 Example of close-up images

Conclusion

This study examined how vision and physical touch affect the evaluation of the tactile properties of knitwear and discovered factors that affect tactile evaluation in a non-touch environment. Through a series of experiments, it was determined that humans can perceive tactile properties similarly when they are able to physically touch the fabric, whether their vision is obstructed or not. Some differences were discovered when participants were able to touch swatches compared to when participants could physically touch and view the sweaters. The results of this study show that size of the material affects the tactile perception of stretchiness and flexibility only when participants' vision was obstructed. When participants were able to freely view and touch the fabric, the size of the fabric (swatch vs. sweater) did not have any impact on the result of all evaluations.

In the experiments where participants evaluated fabrics using only visual materials and haptic experiences, they were unable to accurately perceive the tactile properties of knitwear, especially stretchiness and flexibility. A surface haptic experience can increase the accuracy of stretchiness and flexibility evaluations, but it did not help in the evaluations of fabric thickness and heaviness. This result suggests that further development is needed on haptic devices that attempt to reproduce the surface texture of textiles.

Findings from interviews suggested that the shape, width and number of folds, density, and thickness of the yarn are all major factors that influence the tactile perception of knitwear when participants could only evaluate properties through on-screen visual materials. Based on this insight, more effective visual materials can be developed. If visual materials detailing these specific components are provided in an online shopping environment, consumers may have a better understanding of the product that could reduce the return rate.

There are limitations to the data analyzed in this study. Due to the small number of samples, some evaluations of certain samples were identical, resulting in a standard deviation of zero. To adjust for this limitation, a non-parametric test was conducted following the t-test, which confirmed the results.

This study attempted to objectify the subjective assessment of fabric using statistical analysis. A follow-up study with a larger sample size and point scale is recommended.

The results of this study provide a deeper understanding to how humans create a tactile perception. Findings from this study will contribute to the improvement of the consumer experience in the contact-free shopping environment and can be used as a fundamental guide to human perception of clothing, which can support technologies such as haptic devices, VR, and AR shopping.

Availability of data and material
The data sets used and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests
The authors declare that they have no competing interests.

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Authors' contributions
Both authors developed the research idea. SYJ collected and analyzed the data , and prepared the manuscript. JH guided the overall process of the research and revised the manuscript. All authors read and approved the final manuscript.

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