Getting Insights from Twitter: What People Want to Touch in Daily Life

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Abstract—Understanding what people want to touch in daily life has been one of the central topics in the fields of haptic science, engineering, and marketing. Several studies have addressed the topic, however, their findings were highly dependent on the experimental stimuli in the laboratory environment. In this study, we tried to gain insights into targets that people want to touch in daily life by conducting a Twitter survey. We collected a considerable amount of Japanese Twitter posts containing references to the desire for touch. To capture the motivation underlying these desires in relation to haptic properties, we used several queries that comprehensively covered exploratory procedures. The results showed that targets that people wanted to touch depended on the exploratory procedures in the queries used (e.g., "want to stroke" tended to target people and animals). We also found that these targets were desirable to touch not only for their haptic properties but also as a means of communicating with other people or living animals. Our findings would be important for understanding human haptic function in the real world and for developing consumer haptic displays and applications.

Index Terms—Haptics, Desire for Touch, Social Media, Twitter, Exploratory Procedure

1 Introduction

In daily life, people touch many kinds of targets around them. For example, people touch target surfaces to assess their texture, make physical contact with familiar people or animals for communication, or feel the condition of targets through tools such as pliers. Among these various targets, there are those that people want to touch and those they do not. Understanding what people want to touch in daily life is an important issue from the perspective of understanding human behavior. Also, recognizing the desire for touch is useful for the future development of consumer applications using a haptic display.

Earlier studies have investigated what kind of look and feel of targets motivated people to want to touch them [1], [2], [3], [4]. From the viewpoint of haptic saliency, Metzger et al. [5] investigated what people preferentially touch within an object surface and Lau et al. [6] investigated where on a 3D object people would touch it. Although these studies successfully identified the shapes or textures that induce participants to touch, it still remains unknown to what extent people want to touch such experimentally well-controlled stimuli when they do not have the experimenter's guidance in everyday life. For example, people sometimes want to touch other's body parts such as hands, heads, or shoulders that have largely different shapes and surface properties depending on the communication situation. As another example, they sometimes want to hit/tap a specific product like a drum or a keyboard to get the tactile feedback that largely depends on the material or shape design of those targets. Therefore, in order to understand the desire for touch in daily life, it is necessary to investigate it in the real world. However, conducting a survey of people reporting the desire to touch in daily life is laborious and time-consuming, and is not suitable for collecting a good range of data.

This study focused on a Twitter survey for an investigation in Japan. In recent years, surveys using social media have been receiving increased attention for the light they shed on people's daily activities and moods [7], [8], [9], [10]. Among social media, Twitter [11] has the largest number of users in Japan. Investigation through Twitter has both advantages and disadvantages. Twitter provides a public API and we can obtain a considerable quantity of user-generated tweets. In contrast to the self-reporting in offline experiments, posts on Twitter are not prompted by experimenters and thus there are less experimenter-demanded effects on the posts. On the other hand, there could be noisy text on Twitter since text can be posted by anyone or even by automated posting software. Thus, in this paper, we aim to get insights into what people want to touch by collecting and analyzing data collected via Twitter, while carefully handling noise within the data.

When getting insights into what people want to touch, an understanding of the reason for the desire to touch is also important. From a series of psychophysical experiments [1], [2], [3], [4], it is suggested that the desire for touch has a close relationship with specific haptic properties such as smoothness of texture [3]. The identification of the role of haptic property in the desire would give us a clue as to the reason for the desire. Having said that, it is difficult to identify the haptic properties that characterize a target in a tweet and how they attracted the attention of the user. For example, if the word "box" is extracted as a target of desire, it is hard to estimate what properties – such as global shape or surface texture – are the main factors attracting

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the desire for touch. Here, exploratory procedures seem to be useful for alleviating the problem since it is known that humans use corresponding exploratory procedures to judge a specific haptic property [12], [13]. For example, it is known that people push targets to judge their physical compliance. Based on this knowledge, the target that people want to push might have some characteristics in respect of its softness. In other words, based on the desire related to a particular exploratory procedure, we can speculate and discuss the haptic property that motivates people to touch. To aggregate the desire to touch some target via a specific exploratory procedure, we configure the queries for the Twitter API based on the categorization of the exploratory procedure. We clarify which target is desired for each exploratory procedure in real-world situations by comparing the distribution of target words extracted by each query. Also, we clarify the desire that is fulfilled by a target or particular haptic property by comparing the target words for desire and those for action for each exploratory procedure.

The present study is the first to investigate which targets in the real world attract the desire for touch using Twitter. Even though our data might be biased due to factors such as the use of specific social media or skewed populations in Twitter users in Japan, we believe that our results are valuable for haptic science researchers and for developers of haptic displays or applications. For haptic science researchers, our results can contribute to clarifying how the brain processes the desire for touch. For example, by comparing our results with the findings obtained in the former laboratory experiments, researchers can gain an insight into what missing factors in the laboratory experiment, such as the multi-sensory information that real-world targets have, affect desire for touch. As a more practical example, researchers can prepare real-world stimuli encouraging desire for touch to examine the brain function related to the desire.

For developers of haptic displays or applications, our results can contribute to designing a haptic display realizing social touch or to defining appealing targets for haptic entertainment applications. For example, developers can gain insights on the functional requirements of a haptic display realizing the touch experience for specific targets such as cats or dogs. If the desire for touch is not confirmed with specific exploratory procedures by our analysis, it can be seen that such touch gesture is not required to be supported to satisfy the desire to touch the targets. As another example, developers can see what kind of target in applications appeals most to users with a display that supports a specific property or touch gesture.

2 Related Work

First, we introduce previous studies conducting content analysis using Twitter. Then, we introduce the relevant knowledge on exploratory procedures. Lastly, since our investigation has a close relationship with affective and discriminative aspects of the desire for touch, we introduce earlier investigations into the desire for touch from the perspective of these two aspects of touch.

2.1 Content Analysis using Twitter

Content analysis is an approach to empirical research based on pre-existing content. On Twitter, which is a microblogging tool that is growing in popularity worldwide, there exists a large quantity of tweets in Japanese posted by more than 50.9 million active users of Twitter [14] in Japan. Recently, Twitter surveys have been widely used for a broad range of objectives from stock prediction using sentiment analysis [15] to estimation of drug consumption [16].

As a content analysis technique, it is known that word-frequency lists provide an overview of the words or phrases that occur in an analyzed text a certain number of times to identify the interest of the text. In addition, triangulation of the result with different queries [9], different analyses [17], and qualitative reviews of the sampled text [18] will help to strengthen the validity of the analysis. Following these methods to improve the reliability of the results, we used comprehensive queries in relation to the exploratory procedures to collect data, qualitatively review the text, and triangulate the results with multiple analyses. Also, since the raw tweets are unstructured and noisy [19], we carefully clean them before analysis.

2.2 Exploratory Procedures

The relationship between explorative hand/finger movement and the haptic properties of targets is systematically described in the form of exploratory procedures [12], [13]. Exploratory procedures are stereotypical patterns of manual exploration observed when a human is asked to make judgements about the haptic properties of a particular target. Each exploratory procedure during free exploration was found to be optimal for accurately identifying the corresponding haptic properties. For example, it was reported that "static contact", which is when a skin surface is placed against a target without moving, was usually performed for judgment of the warmth or coolness of a target and this is because it is suitable for the judgment of temperature. Other exploratory procedures include "pressure" (related to softness/hardness), "unsupported holding" (weight), "enclosure" (volume, shape), "lateral motion" (texture), and "contour following" (contour). In this study, multiple queries corresponding to the exploratory procedures were used to triangulate the results.

2.3 Affective and Discriminative Aspects of Desire for Touch

Touch has been described as having two different aspects: discriminative and affective [20]. The discriminative aspect of touch helps us to discriminate the haptic property of a target. Aβ afferents, which are myelinated and thick, convey the discriminative aspect of touch to the brain. In addition to the discriminative aspect, touch was also proven to provide affective inputs to the human brain, which are key for emotion-related communication and social interactions. CT afferents, which are unmyelinated and thin, contribute to the affective aspects of touch [21]. For a comprehensive understanding of the desire for touch, it is important to analyze the desire in relation to these two aspects.

These two aspects of touch are receiving attention not only within haptic science but also in the field of marketing.

Peck and Childers [22] have created the "Need for Touch" scale, which is a scale that represents individual preferences of the need for touch. Their scale is composed of two subscales: the instrumental scale and the autotelic scale. Instrumental NFT corresponds to the discriminative aspects of desire for touch, originating from goal-directed motives to play a role in making the judgment. Meanwhile, autotelic NFT corresponds to the affective aspect of desire for touch which corresponds to the hedonic feeling induced by touching a product. Since it was reported that the participants having higher instrumental NFT, rather than autotelic NFT, tended to rate targets as more inviting and pleasant in feeling [4], instrumental and autotelic aspects might have different roles in the desire for touch. Thus, discussing our results in terms of discriminative (instrumental) touch and affective (autotelic) touch would be useful for understanding touch motivation in the realms of haptic science and haptic marketing.

3 Collection and Preprocessing

The flow of our investigation consisted of collection, preprocessing, and analysis stages as shown in Fig. 1. The collection and preprocessing stages are described in this section. In the next section 4, the analysis stage is described.

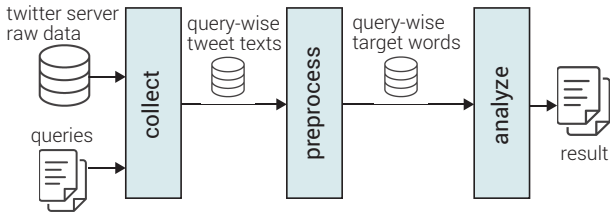

Fig. 1. The flow of investigating what people want to touch comprises collection, preprocessing, and analysis stages.

3.1 Collection

Tweets over 150 days (From September 12, 2020, to February 9, 2021), were collected using the Twitter API by feeding queries. To avoid collecting duplicate tweets, an additional parameter of the API was configured to exclude retweets (relays of tweets by another Twitter user) or replies to other users.

To collect tweets indicating the desire to touch related to each exploratory procedure, we defined base verbs that comprehensively covered the exploratory procedures (shown in Table 1). In the leftmost column of Table 1, the exploratory procedures are described. Corresponding haptic properties and base verbs are described in the next two columns. In total, we prepared 11 base verbs. Though the original exploratory procedures [13] did not include a verb corresponding to "tap" or "hit", it is known that humans recognize the hardness of a target by tapping or hitting the target surface and observing the damping natural vibration or reactive impulsive force [23], [24], [25]. Thus, we adopted "tap/hit (tataku in Japanese)" as an additional base verb capturing hardness. We also adopted the more general base verb "touch (sawaru in Japanese)", that can be considered to be less dependent on specific haptic properties. Comparing target words between "touch (sawaru in Japanese)" and the other base verbs would be useful for determining characteristic target words for each base verb.

TABLE 1
The base verbs corresponding to exploratory procedures. The queries were combinations of a base verb with "want to" or the past tense of a base verb. The number of extracted tweets per query is given in each cell.

exploratory procedure	haptic property	base verb *(in Japanese)*	number of collected tweets per query	
			desire queries ・want to ~ *(~tai)*	action queries ・past tense *(~shita)*
general	general	touch *(sawaru)*	95137	174038
static contact	temperature	statically contact *(fureru)*	33335	147128
lateral motion	texture	stroke *(naderu)*	22134	13125
lateral motion	texture	rub *(kosuru)*	358	3192
unsupported holding	weight	lift *(mochiageru)*	1533	12788
unsupported holding	weight	support *(sasaeru)*	15480	36017
enclosure	global shape, volume	grasp *(tsukamu)*	12194	74690
enclosure	global shape volume	cover *(oou)*	574	10943
pressure	softness	push *(osu)*	12892	175735
pressure	hardness	hit/tap *(tataku)*	4011	52664
contour following	global shape, exact shape	trace *(nazoru)*	2283	7165

We defined the queries by combining the base verbs with the additional verb "want to" with which we aimed at directly capturing the desire for touch. Hereinafter we simply call these queries "desire queries". Though we attempted to use other queries combining the base verbs with additional verbs such as "like to" or "feel good to" with which we aimed at indirectly capturing the desire to touch, the extracted number of tweets was too small to analyze and we did not use the texts extracted by those queries. Also, we used queries using the past tense of the base verb (e.g., "touched") to capture the touch action. Hereinafter we simply call these queries "action queries".

In total, we prepared 22 queries (=11 base verbs $\times$ 2 (desire and action queries)). The numbers of tweets extracted per query are shown in the cells in Table 1. The number of tweets for desire queries corresponding to "want to rub" and "want to cover" were lower than 1500, which equated to 10 occurrences per day and the sample was too small to analyze. Thus, we did not use the tweets extracted by queries using the base verbs "rub" or "cover" for further analysis.

3.2 Preprocessing

The flow of the preprocessing stage is shown in Fig. 2.

3.2.1 Tweet exclusion

To avoid the double count of tweets posted by a bot (a bot is a type of software that controls a Twitter account via the

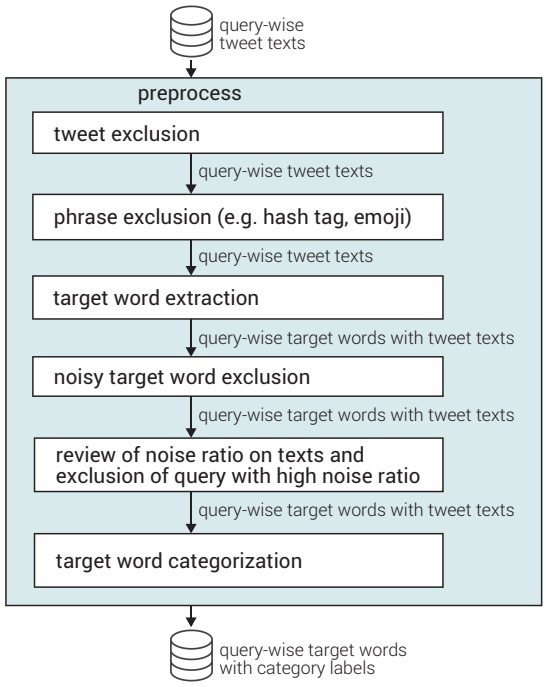

Fig. 2. Flow of the preprocessing stage.

Twitter API. The bot software can autonomously perform actions such as tweeting and retweeting) or by users who tweet the same thing repeatedly, we excluded tweets with the exact same content. To exclude ads and spam, tweets that contained URLs were excluded.

3.2.2 Phrase exclusion

Further, a per-phrase within tweet exclusion process was employed. Non-Japanese phrases, hashtags (phrases written with a # symbol used to index keywords or topics on Twitter), emojis, and emoticons were excluded.

3.2.3 Target word extraction

After these processes were executed, target word extraction was performed. This process depended on the NLP for Japanese sentences. The Japanese language is a language without word boundaries, and therefore, a morphological analysis was performed using Juman++ [26]. To find the words that were dependent on the base verbs, a dependent structure analysis was performed using the Kurohashi–Nagao parser (KNP) [27]. A case structure analysis was then performed on the identified words to determine the target word. Finally, to confirm that the target was a noun, we confirmed whether the word exists in the word2vec [28] model provided by chiVe [29].

At this phase, the number of target words for the query "want to lift" was 56 and we decided not to use the base verb "lift" since it was difficult to analyze such a small number of target words.

3.2.4 noisy target word exclusion

We conducted qualitative reviews [18] of the target words and texts, and we noticed that there were noisy texts present that did not show the desire to physically touch. For example, the tweets extracted by a query of "want to support" included many texts that referred to the intention to help a specific person.

To exclude such noisy texts, it would be best if automated exclusion to check texts were possible, but it was difficult to implement a system that could accurately judge texts as noise or not automatically. In contrast, manual inspection of all of the tweets would be accurate but too time-consuming to apply. Thus, we adopted a third option; we configured a noisy target word list per query that would be excluded and excluded the tweets that contained such noisy target words. Note that if a tweet containing a target word could not always be determined to be noisy, the target word was not added to the noisy target word list. In other words, the target word in some cases could not be excluded as noise. For example, "want to hit the keyboard" can mean both "want to play the keyboard" and "want to feel the feedback when hitting the keyboard" and it is difficult to discriminate. In such a case, we did not exclude the target word. After defining the noisy target word list, we excluded tweets with target words that were included in the list.

3.2.5 review of noise ratio on texts and exclusion of query with high noise ratio

After noisy target word exclusion, we reviewed the texts to test how many noisy texts that did not represent the desire for physical touch were included in the dataset. We randomly sampled 500 tweets per query and counted the noisy text ratio among them. As a result, the noise ratio for the query related to the base verb "support" was too high (e.g., 78 % for "want to support") and that ratio for the queries corresponding to other exploratory procedures were less than 1.6 % at most. Thus, we decided to use all queries except for ones whose base verb was "support". In total, the target words extracted by 14 queries (=7 base verbs $\times$ 2 (desire and action queries)) were used for analysis.

After all of these steps were completed, the target word was automatically translated into English using the Google Translate API. If the word was not appropriate for academic reporting, we reworded it into a more suitable one.

4 Analysis Results and Discussion

4.1 Analysis on Desire at Target Level

We first visualized the distribution of occurrence probability of target words for each desire query in Fig. 3. The figure shows how each different query captured the different target words. Here, to make it clearer which target words characterize each desire query, we have shown the top 10 target words extracted by each desire query in descending order of occurrence probability in Table 2. The target words in Table 2 seem to be dependent on the desire query. For example, "button" was the most frequently tweeted target word among target words extracted by the desire query "want to push", but "button" was not frequently extracted by the other desire queries. We would like to confirm how significant each target word was for each exploratory procedure, but the challenge was how to define the control condition. To statistically evaluate the significance of the words for each desire query, we calculated the differences in a word's occurrence probability between cases when the word was extracted by the focused desire query and cases

TABLE 2
Target words in descending order of occurrence probability for each desire query. Blue target words denote that the words' occurrence probabilities in each EP (Exploratory Procedure) desire query were larger than those in the general desire query "want to touch", which suggests that the target words characterize the EP desire query. Red target words denote that the words' occurrence probabilities in each EP desire query were smaller than those in the general desire query "want to touch", which suggests that the target words characterize the general desire query.

desire query	target word in descending order of occurrence probability for each desire query									
	1	2	3	4	5	6	7	8	9	10
want to touch	breast	hair	buttock	cat	abdomen	cheek	dog	body	ear	hand
want to statically contact	**you**	**people**	**skin**	**cat**	**hand**	**warmth**	**animal**	**human skin**	**object**	**lip**
want to stroke	**head**	**cat**	**dog**	abdomen	**buttock**	**hair**	**me**	**back**	**child**	**cheek**
want to push	**button**	**stamp**	**cart**	**abdomen**	card	whorl	**key**	**everyone**	mole	**chair**
want to hit/tap	**drum**	**buttock**	**keyboard**	**head**	hand	shoulder	something	**iron**	**them**	**cheek**
want to grasp	**waist**	**hand**	buttock	**tail**	**arm**	hair	**ankle**	breast	**tongue**	leg
want to trace	**line**	**abdominal muscle**	**eyebrow**	**muscle**	**back**	**clavicle**	**blood vessel**	**crack**	**tooth**	**ditch**

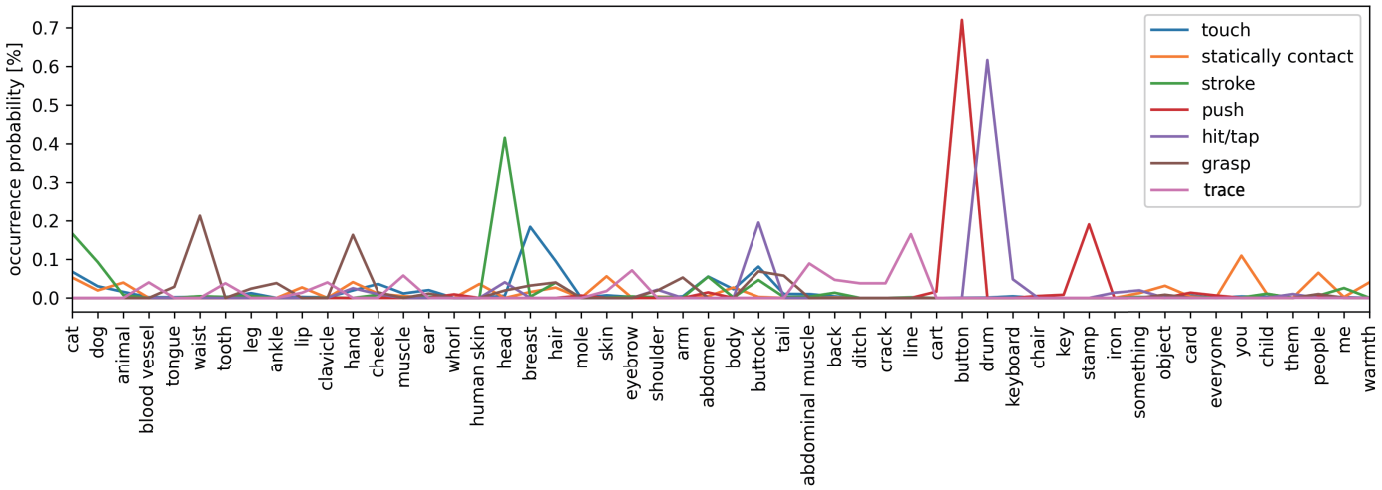

Fig. 3. Distribution of occurrence probability for each desire query for target words ranked in the top 10 for either desire query. This shows how the distribution differs depending on the desire query.

when the word was extracted by the general query "want to touch". The comparison with the occurrence probabilities of target words in the general query, which is considered to be less sensitive to specific haptic properties, will allow us to determine the characteristic words for the focused queries. We calculated 10000 bootstrap samples [30] of the differences. If the Bonferroni-corrected 95% confidence interval (CI) of the difference did not overlap to zero, we could conclude that the difference was statistically significant. In Table 2, target words the CI of which was greater than zero are colored in blue, which indicates the target word occurred more frequently in the case of a focused desire query than in the case of the "want to touch" query. In contrast, target words the CI of which was less than zero are colored in red, which indicates the target word occurred less frequently in the case of a focused desire query than in the case of the "want to touch" query. The statistical analysis supported the observation above that each EP desire query has distinctive target words, i.e., there are a lot of tweet texts such as "want to statically contact you", "want to stroke head", "want to push button", "want to hit (i.e., beat) drum", "want to grasp waist", and "want to trace line". Moreover, even between base verbs of "hit/tap" and "push", both of which belong to the same exploratory procedure for capturing hardness/softness, the popular targets obtained were different. This result does not support the assumption that people want to acquire different properties (e.g., softness or shape) of the limited popular target (e.g. hand) via the different exploratory procedures. On the other hand, some words triggered desires across some different desire queries. For example, "cat" was extracted as one of the top words by the desire queries whose base verbs were "touch", "statically contact", and "stroke". This means that people want to confirm at least both corresponding haptic properties, i.e., the temperature and the texture, of the cat.

Fig. 4 shows the occurrence probabilities for the top 10 target words for each desire query. It indicates that a small number of specific target targets form the majority of the desire, but the extent of the concentration of desire depended on the queries. For example, the occurrence probability of the top target word in the case of queries of "want to push" and "want to hit/tap" were more than 60 % of all desires. It is interesting that both "want to push" and "want to hit/tap" are the exploratory procedures for confirming the

softness/hardness of a target. In daily life, there may be a limited number of cases where the action to confirm the softness/hardness is performed.

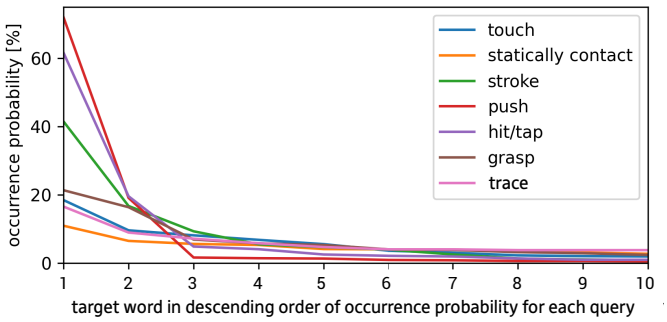

Fig. 4. Occurrence probability for target word in descending order.

Extracted target words include those related to body parts. Which body part people want to touch depends on the desire queries as can be seen in Table 2 and Fig. 3. For example, the waist is desired to be touched mainly via grasping rather than via other exploratory procedures. We visualized the geometric relationships between base verbs based on the body parts by mapping them into a whole-body illustration (Fig. 5). Note that, though the target words about body parts included not only the human body but also other living things such as animals, we have selected the human body as an example. In this figure, each base verb was mapped to body parts where the rank of the occurrence probability in the desire query using the base verb was higher than that in the "want to touch" query. For example, we mapped "stroke" to head since the rank of the occurrence probability of head was higher in the desire query "want to stroke" than the rank in the desire query "want to touch". In addition, we mapped "touch" when the rank of the occurrence probability of the body part was higher than that for other queries. Moreover, since "breast" and "ear" were among the top 10 in the desire query "want to touch" but were not in other desire queries, we mapped those body parts as desired targets of touch. These results might indicate the relation-specific aspect of the exploratory procedure. An earlier study showed that the hands and arms were relatively touchable for people who are not close to the owner while the breast, abdomen, and buttock were touchable only for people who are very close to the owner [31]. Thus, touching (for breast and abdomen) and hitting (for buttock) might be behaviors reflecting intimacy with the owner of the body parts (as long as the behaviors are performed for body parts). It would be one interesting direction to investigate the relation-specific exploratory procedure for body parts.

4.2 Analysis on Desire at Target Category Level

To conduct the analysis not only in terms of individual target words but also in terms of the target category, we categorized each target word under our defined categorization.

Initially, we conducted a hierarchical clustering of the target words and attempted to use the resulting cluster as a categorization. We converted the word to vector using

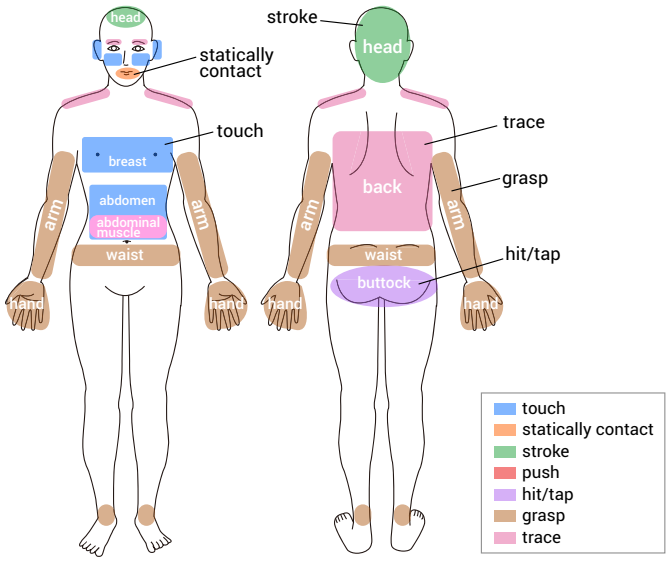

Fig. 5. Mapping of base verb of desire query to human body parts.

word2vec model [28] and used the vectors as the input information of a clustering algorithm. We conducted hierarchical clustering using Ward [32]'s method with squared Euclidean distance as the distance measurement. The result of the hierarchical clustering for targets extracted by each query is shown in Supplemental materials. Here, we found the clustering results seem to be less clear and intuitive. (For example, "warmth" and "human skin" were classified into the same cluster). This could be partly attributed to the word2vec models. The word2vec model assumes that words occurring in the same contexts tend to have similar meanings. The fact that human skin and warmth often appear in the same context suggests that warmth often appears in the sense of temperature of human skin. However, warmth does not always mean human skin. As with this example, clustering based on co-occurrence relationships seems to fall into a less-accurate classification.

Instead of using the result as is for categorization, we referred to the result and manually defined the following six categories: (1) body part, (2) animal, (3) object, (4) person, (5) geometry, and (6) temperature. The example words are shown in Table 3. We framed the target words into these six categories and used them for further analysis. Since we defined the category bottom-up fashion, these categories are not mutually exclusive and exhaustive. To make clear the dependency between categories, we tried to divide them into affective and discriminative touch [20]. The results are illustrated in Fig. 6. Since touch in relation to a "person", "animal", or "body part" would be related to communication, we classified touch in these categories under affective touch. Since touch in relation to an "object" or "geometry" would be related to the judgment of haptic feeling or tool manipulation, we classified touch in these categories under discriminative touch. "Temperature" would be related to both judgment of a target's temperature property and body temperature felt by physical contact, and thus, we judged that touch in respect of "temperature" has both aspects of affective and discriminative touch.

We computed and visualized the desire occurrence prob-

TABLE 3
Example words belonging to each category.

categories	example words
body part	hand, hair, buttock, abdomen, ear, tongue, arm, ankle
animal	cat, dog, animal, bird, tiger, sheep, carp, cow, hamster
object	button, keyboard, stamp, card, stroller, stone, iron, clock
person	you, people, them, child, female, character, daughter
geometry	line, ditch, crack, border, edge, region, shape, surface
temperature	warmth, heat, temperature, hot air, body temperature

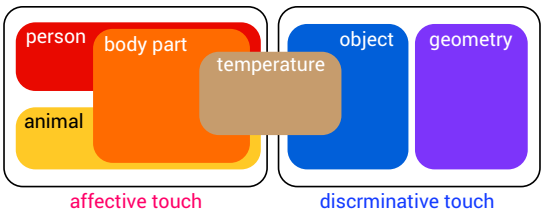

Fig. 6. Relationship between categories.

ability of each category as shown in Fig. 7. The results suggest that the desire queries were different not only on target word levels (Fig. 3) but also on category levels.

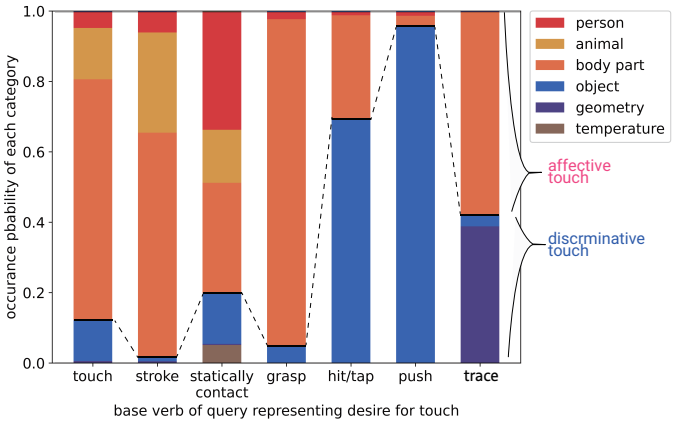

Fig. 7. Ratio of occurrence probabilities of target categories for each desire query.

We determined categories characterizing each desire query by using a bootstrapping method for the differences in occurrence probabilities of each category between focused desire queries and the "want to touch" query. By calculating 10000 bootstrap samples of the difference and the Bonferroni-corrected 95% CI, we tested if the difference was significant. The check marks in Table 4 show the categories where the Bonferroni-corrected CIs did not overlap with zero (i.e., we could judge whether each category characterized the query).

These results show that the target categories that triggered desires were different between desire queries and that the categories were comprehensively covered by the desire queries. Under the assumption that each exploratory procedure is used to feel a specific haptic property (e.g., statically contact to feel temperature), we might be able to speculate the following tendencies:

- when people want to feel temperature by static contact, they want to feel the temperature of someone or something;
- when people want to feel texture by stroking, they want to feel the texture of an animal or person;
- when people want to feel hardness by pushing, hitting, or tapping, they want to feel the hardness of a target;
- To feel the contour of some geometry, people want to trace its line/contour.

Of course, there are cases where we cannot speculate the reason for touch based only on the exploratory procedures related to haptic properties. For example, when people want to grasp a hand, it is not always for the recognition of the hand's shape, it may be for communication with someone.

TABLE 4
Target categories characterizing each desire query. A checkmark(✓) denotes that the occurrence probability of the category for the query was significantly higher than the probability of the target word in the "want to touch" query.

query	body part	animal	object	person	geometry	temperature	affective or discriminative touch?
want to statically contact				✓		✓	affective
want to stroke		✓		✓			affective
want to push			✓				discriminative
want to hit/tap			✓				discriminative
want to grasp	✓						affective
want to trace					✓		discriminative

■Note:
when "body part" , "animal" or "person" is checked, the base verb was characterized as affective touch.
when "object" or "geometryr " is checked, the base verb was characterized as discriminative touch.

In addition, considering that the target category of "person", "animal", or "body part" are regarded as target of affective touch, and the target category of "object", and "geometry" are regarded as the target of discriminative touch (see Fig. 6), we can characterize which affective touch or discriminative touch was dominant in each desire EP query. The touching, stroking, statically contacting, and grasping are exploratory procedures desired for affective touch. The hitting/tapping and pushing are exploratory procedures desired for discriminative touch. In contour-tracing, while the tracing is characterized as discriminative as compared to touching as shown in Table 4, the proportions of affective touch and discriminative touch are comparable as shown in Fig. 7. In total, the ratio of affective touch is dominant. It can be speculated that Twitter users have a tendency to want affective touch, which means that they are somewhat autotelic. Thus, the result of our survey might be more suitable to explain tendencies for those who are autotelic. Since it is known that there are individual differences in the desire for touch as clarified in NFT research [22], it would be important to investigate what non-autotelic people want to touch and compare it to our results as future studies.

On the other hand, the desires for touch that were classified as discriminative touch might include affective nature. Since, to some extent, people have knowledge about the haptic properties of everyday targets (e.g., size-/ material-weight illusions [33], [34] and the memory softness ef-

fect [35]), people do not need to touch them every time to gain this information. Nevertheless, our results showed that Twitter users represent their desire for touch via the exploratory procedure (i.e., the optimal way to gain maximum haptic information), which might show that people tweeted their desire to enjoy the feeling of the targets classified as discriminative touch. Also, there is no forced, specific discriminative task (e.g., detecting a ripe one among fruits), and thus the tweets might reflect the spontaneous desires of Twitter users. Comparing extracted targets in this study to those in future laboratory experiments in which participants perform discriminative tasks would be important to make it clearer whether all the tweets are more affective.

4.3 Comparison between Desire and Action

We compared the desire for touch to the action for touch to assess how much the desire to touch was "fulfilled". We computed the difference of target words' occurrence probabilities between cases of desire queries (e.g., "want to touch") and action queries (e.g., "touched"). We sorted the target words by the difference value obtained by subtracting the occurrence probability of the desire query from the probability of the action query. The top five positive and bottom five negative target words are shown in Table 5. For example, in the case of the base verb "statically contact", the target word "you" took the positive maximum value. In that case, the probability of desire query was superior to the probability of action query and it implies that the desire to touch someone called "you" was not easily fulfilled. On the other hand, the target word "hair" took the negative minimum value. In that case, the probability of desire query was inferior to the probability of action query and it implies that the desire for touching hair was easily fulfilled or even that there was a lack of desire.

We also conducted a bootstrapping method in a similar way as described above, to determine which top or bottom five target words had a difference in occurrence probability between desires and actions. The target words the CI of which did not overlap with zero are colored in blue, which indicates the desire or action frequently occurred.

We found that the relationship between the order of most desired target shown in Table 2 and the order of the target shown in Table 5 varies with base verbs. For example, in the case of base verb "statically contact", the most desired target was "you" (see Table 2) and also the 1st-ranked word was "you" shown in Table 5. The results might reflect the fact that many people want to touch familiar people, but the desire is not always satisfied. In contrast, in the case of the base verb "push", the most desired target was "button" but people much more frequently reported that they actually pushed buttons.

TABLE 5
The difference in the desires and actions for target words for each query. Five target words are shown in descending order of differences. Blue target words denote that probability of desire for the target was significantly higher than probability of touch action for the target. Black target words denote that there was no difference between desire and action.

query		target word in descending order of difference magnitude between desire and action				
		1	2	3	4	5
touch	excessive desire	breast	hair	abdomen	cheek	buttock
	lack of desire	ball	face	eye	nose	head
statically contact	excessive desire	you	cat	people	human skin	animal
	lack of desire	hair	hand	outside air	water	shoulder
stroke	excessive desire	cat	dog	buttock	abdomen	me
	lack of desire	head	cheek	hair	back	face
push	excessive desire	stamp	abdomen	cart	whorl	mole
	lack of desire	button	key	card	stroller	back
hit/tap	excessive desire	drum	buttock	something	iron	keyboard
	lack of desire	hand	knee	shoulder	head	back
grasp	excessive desire	waist	buttock	tongue	ankle	hair
	lack of desire	arm	hand	shoulder	wrist	hem
trace	excessive desire	abdominal muscle	muscle	eyebrow	blood vessel	clavicle
	lack of desire	lip	photo	edge	line	contour

5 General Discussions

5.1 Discussions from Viewpoint of Base Verb of Query

5.1.1 What People Want to Touch

Although we adopted the "want to touch" query as a control condition, not the main factor, the results of the desire query provide some insights for discussion.

Approximately 68.5 % of the occurring target words were categorized to the body part category (see Fig. 7). In accordance with the higher frequency of the body part category, we found some body part words such as breast, hair, buttock, abdomen, cheek, body, ear, and hand were the target of the desire to touch (see Fig. 2). We found that the soft body parts such as breasts or buttocks were ranked higher than hard body parts such as bones or muscles. The result of the higher rank of softer body parts is in line with the results in a previous study [36] showing that the perceived magnitude of pleasantness increased monotonically as a function of increasing compliance of human skin-like rubber objects.

From the viewpoint of the difference between desire and actions shown in Table 5, the target words that people have an excessive desire to touch showed a similar tendency to the target words for the mere desires shown in Table 2. In contrast, Table 5 shows that the target words that people have less desire to touch were head-related parts such as the face, eyes, nose, and head. It can be speculated that these head-related parts might refer to those parts of their own body since it is unlikely that people frequently touch the eyes and nose of other people or animals. For example, to relieve itchy eyes or nose, people frequently and easily perform touch actions in daily life and the desire to touch

these body parts would be easy to fulfill.

5.1.2 What People Want to Statically Contact

We found that "person" and "temperature" categories frequently became the target of static contact desire queries (see Table 4). As example words in the "person" category, we found "you" and "people" were ranked in 1st and 2nd places among target words (see Table 2). As an example word of the "temperature" category, we found "warmth" was ranked in 6th among target words. From the viewpoint of comparison of desire with action, we can observe that not only people but also animals trigger desires for static contact (see Table 5). Based on the knowledge that the exploratory procedure of static contact corresponds to the temperature as a haptic object property [13], there is a possibility that the temperature people want to appreciate is usually the human or animal's body temperature.

5.1.3 What People Want to Stroke

From the categorical viewpoint, the animal and person categories statistically characterized the desire query "want to stroke" (see Table 4). Note that the occurrence probability of the body part category was still higher than that of the animal or person (see Fig. 7).

We found that the highest-ranked target words were head, cat, and dog (see Table 2). From the viewpoint of haptic properties, considering that the exploratory procedure of stroking is known to be performed to judge the texture [13], Twitter users might want to appreciate the hair-related texture. These results can be explained by the combination of previous psychophysical results [4], [37]. Previous studies showed that smoother rather than rougher [4] surfaces invite participants to touch. In addition, fur or wool is perceived to be smooth [37]. The combination of this knowledge shows that the skin covered with soft hair can be felt smooth and invites touch. It is considered significant in the sense that the results of psychophysical experiments that have been verified in the laboratory with carefully controlled stimuli can be reproduced in the real world as well.

From the viewpoint of the difference between desire and actions shown in Table 5, the target words that people have an excessive desire to stroke show a similar tendency to the target words for the mere desires shown in Fig. 2. Interestingly, most of the targets that were reported to be stroked and were lack of desire were head-related targets such as head, cheek, hair, or face. Compared to the abdomen and buttocks, these head-related targets are exposed and it seem to be more acceptable to stroke them, even in a relatively distal relationship.

5.1.4 What People Want to Push

From the categorical viewpoint, the "object" category was the dominant desired category for push and there were less desires in relation to body parts (see Fig. 7 and Table 4). This is different from other queries that included a certain amount of desire in relation to body parts. Most of the desired target words for push were buttons and stamps (see Table 2 and Fig. 4) and the sum of those two words attained 90 %. In particular, the desire for buttons was more than 70 %, and thus we discuss mainly about buttons.

From the result of the difference between desires and actions, the action of pushing a button was the most performed of all actions of pushing something. This might be due to the fact that there are various physical buttons around people such as those in elevators or on TV Remote Controllers, and the pushing of buttons is performed on a daily basis.

On the other hand, currently, physical buttons as user interface devices are being replaced by touchscreens. For example, mobile phones with physical buttons or keyboards prevailed until the 2000s, but touchscreen-only devices were popularized in the 2010s [38]. For another example, car-makers are now replacing buttons with touchscreens on dashboard infotainment systems. 98.8 % of all new cars sold in the US have a touchscreen display [39]. In contrast to the current undergoing replacement of physical buttons by touchscreens, our results suggest that there is and will be a desire for the action of pressing physical buttons. There are research studies on presenting tactile button feedback when touching a touchscreen [40], but this is still in the research phase, and thus we can expect that people will still tend to want to push buttons more and more in the future.

We must be noted that the desire for pushing a button does not always mean the desire for the tactile feeling of the button. In some cases, people just expect the result accompanied by pushing the button. The reason behind the desire is difficult to understand with the investigation into Twitter posts and an offline experiment is needed.

5.1.5 What People Want to Hit/tap

From the categorical viewpoint, the "object" category triggered most of the desires for hit/tap (see Fig. 7 and Table 4) as in the case of those for "push". The similarity between hit/tap and push seems to be reasonable since both push and tap/hit are exploratory procedures related to hardness/softness. The dominance of a small number of target words was observed in Fig. 4 and it was also similar to the "push" query.

Focusing on the target words, drum and buttock were popular, and these two words accounted for more than 80% of all desires (see Table 2 and Fig. 4). Some words indicating musical instruments such as drums or keyboards have been extracted and we recognize that hitting a percussion instrument is one of the popular hitting use cases. However, in this case, the reason behind the situation of "hitting the percussion" was not clearly distinguishable between people wanting to feel the hardness of the instrument and those actually wanting to play the percussion instrument.

From the viewpoint of the difference between desire and actions shown in Table 5, the target words that people have excessive desire to hit/tap have a similar tendency to the target words for the mere desires shown in Table 2. In contrast, the target words that people actually did hit/tap and had less desire to do so (i.e., a lack of desire) were body-part words such as hand, knee, shoulder, head, and back. The use case when people do not want to hit/tap body parts but they nevertheless do is considered to be caused by negative factors. Scolding children would be one of such cases.

5.1.6 What People Want to Grasp

From the categorical viewpoint, the body part is the dominant category for the desire to grasp (see Fig. 7 and Table 4). Out of all the desire queries, the "grasp" desire query had the highest ratio of body parts category words (see Fig. 7).

Paying attention to each target word, waist, hand, tail, arm, ankle, and tongue were the distinctive target words for the grasping desire query (see Table 2). The results appear plausible because it is easy to imagine how people grasp these particular body parts as compared to other body parts extracted by other desire queries such as abdomen or cheek. Also, when we look at the illustration mapping the grasping desire query to the whole body (Fig. 5), we can notice that these body parts are relatively located at the limbs, which are more exposed and easy to grasp.

Focusing on the difference between desires and actions for target words shown in Table 5, the body parts which are somewhat sexual were ranked such as waist, buttock, and tongue. The top two target words that triggered a relative lack of desire but were reported to be frequently touched were arms or hands. It is known that the bodily regions where one may touch different individuals in their social network are relationship-specific [41]. According to an earlier study [31], arms and hands rather than other body parts are allowed to be touched by even emotionally distant acquaintances and thus, these two might be ranked high.

5.1.7 What People Want to Trace

From the categorical viewpoint, the ratio of target words attributed to the geometry category was higher (see Fig. 7 and Table 4). The words such as line, crack, or ditch (shown in Table 2) were not shown by the other desire queries. This geometrical word occurrence appears plausible since the aim of contour-tracing as an exploratory procedure is to capture the contour of targets.

In addition to the geometric target words, we can observe the hard target words that are neither soft nor deformable such as abdominal muscle, muscle, clavicle, and tooth in Table 2. As compared to the soft targets extracted by other queries, the results show that hard targets characterize the desire query of tracing. Focusing on the difference between desires and actions for target words shown in Table 5, the muscle parts attracted people's attention but people also have less opportunity to access the muscles.

5.2 Insight into Haptic Displays or Application Development

Based on our results, we can gain insights into haptic application development that would help developers of haptic displays or applications. Here, there are two points to note. First, we focus on haptic applications for entertainment purposes when people touch and feel something that they want to touch and feel, while there are three application categories: training, assistance, and entertainment [42]. Second, the result of this study is obtained from a Twitter user population which is skewed (see next Section 5.3). Still, our result would help developers in two ways: (1) defining targets in haptic applications and (2) defining requirements of haptic displays.

First, our results would help developers to define the target for which their application provides a touch experience. Our results in Table 2 or Table 4 show which targets would appeal to users for each exploratory procedure or haptic object property. For example, in the case of the "hit/tap" exploratory procedure, some words such as drums or keyboards indicating musical instruments have been extracted at top rank, which suggests that hitting a percussion instrument would be one of the appealing hitting/tapping use cases. There is already some research addressing haptic feedback when using percussion instruments [43], [44] and our result would support the motivation of these studies. Such information would contribute to companies developing haptic applications based on a market-in approach [45] and also help researchers to configure demonstrations of newly proposed haptic displays. We also found relatively fewer tweets representing desires to touch targets that cannot be touched in the real world (e.g. fire and magical orbs). If we can define a query that can collect a lot of these tweets, we will be able to investigate the desire to touch things that do not exist and cannot be touched in the real world, beyond laboratory stimuli and daily targets. This direction is important for understanding what kind of content creates touch desire and to create an appealing haptic application.

Second, our results would also contribute to the requirement definition of haptic displays that could capture people's desire to touch. We discuss a temperature display as one of examples. According to the Table 2 and Table 5, we confirm that the people or animal category targets are popular with the exploratory procedure of static contact. Based on the knowledge that the exploratory procedure of static contact corresponds to temperature as a haptic object property [13], there is a possibility that the temperature people want to appreciate would usually be a human's or animal's body temperature. Although currently one of the research directions regarding thermal displays is to speed up the response time of temperature change utilizing techniques such as water cooling [46], [47], [48], in the cases for detecting and presenting body temperature, dynamic temperature changes may not be necessary.

Unfortunately, from the viewpoint of requirement definitions, we found some targets for which it would be difficult to realize a touch experience using current haptic displays to comprehensively satisfy user's desires. Our results suggest that there are some targets that are popular across multiple properties. For example, the hand was extracted by the desire queries whose base verbs were "touch", "statically contact", "hit/tap", and "grasp". This means that people want to appreciate the temperature, softness, and shape of the hand. This suggests the difficulty in providing a comprehensive experience of touching a cat or hand with haptic displays. Since each haptic property is delivered by a different type of actuator, which has its own volume, the integration of haptic displays would cause spatial interference issues [49]. Moreover, sensing multiple exploratory procedures makes display development difficult.

5.3 Limitations

To the best of our knowledge, this study is the first to utilize Twitter data to discuss people's desire to touch in

their daily lives. The analysis provided some insights into desires in relation to targets or target categories, which were previously unknown. This was enabled by the large amount of data on "what people want to touch," posted publicly by Twitter users. However, there are several limitations to the current study.

This study only covers Twitter users; it does not cover those who do not use Twitter and those who do not use social networks at all. In addition, the age or gender distribution of Twitter users is skewed relative to the distribution of the real-world population (see Supplementary Table for detail). Moreover, it is also difficult to know the age and gender of specific tweet authors since that information was not provided by the API. If a robust method of estimating a Twitter user's age and gender is developed in the future, we will be able to further analyze the desire for touch in terms of age and gender.

Note that the touch desire analyzed in this study was only the specific part of desire that Twitter users have in their daily lives. The desire that the Twitter user wanted to share with the public was posted to Twitter.

The method we used and the results obtained in this study are assumed to be Japanese-specific. This is because only tweets written in Japanese were collected. Furthermore, the touch needs or the role of touch in different cultures are different [50]; for example, in Italy, a hug and kiss on each cheek are considered a common and acceptable form of greeting. In contrast, in Japan, a proper greeting comprises a bow and the absence of any haptic contact [51], [52]. Thus, the results would be different even when the same method is applied to different cultures.

In addition, we analyzed data collected in a certain period between 2020 and 2021. There is a possibility that the data was affected by time factors such as seasonality. Also, there is a possibility that the desire for touch may be biased by restrictions on travel and by social distancing due to COVID-19 situations. To clarify this, one future study topic is to test whether the result would be changed or unchanged by the time period for data collection.

6 Conclusion

This study aimed at investigating what people want to touch in daily life. We collected texts in Japanese from Twitter because there is a considerable amount of posted text representing user's desires on that platform. We carefully denoised the text and triangulated the results with multiple queries corresponding to exploratory procedures or multiple analyses. The results suggest that the target of desire depends on the exploratory procedures on both target level and category level. Some previously-obtained findings suggesting a preference for soft targets were also observed in our results while other findings suggesting a preference for metallic targets were not observed in our results. In addition, our results could give insights into haptic display or application development because they show which target is desired for each exploratory procedure or haptic property. To the best of our knowledge, this is the first study that used Twitter data for discussing touch desires and it suggests the possibility of using Twitter for understanding human touch behaviors.

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