2025 IEEE World Haptics Conference (WHC)
Suwon Convention Center, Suwon, Korea
July 8 ~ 11, 2025

Exploring the Emotional Responses to the Sounds of Organic Affective Touch

Francisco BARBOSA ESCOBAR
Sorbonne Université, CNRS,
Institut des Systèmes Intelligents et de Robotique,
Paris, France
barbosaescobar@isir.upmc.fr

Malika AUVRAY
Sorbonne Université, CNRS,
Institut des Systèmes Intelligents et de Robotique,
Paris, France
malika.auvray@sorbonne-universite.fr

***Abstract*—Haptic cues are crucial in the elicitation of emotions, as affective touch research has revealed. However, our increasingly digital lives have eroded access to these cues, having detrimental effects. Thus, the investigation of alternative ways to elicit equivalent emotional responses to those of affective touch merits attention. In the present study, two online experiments examining the emotional responses to sounds of organic affective touch were conducted. In Experiment 1, the emotional responses to a series of organic affective touch sounds, compared to object-based sounds, were evaluated. In Experiment 2, the influence of manipulating the stated nature of the sounds, as either affective touch or object-based, on the emotional responses to the sounds was investigated. The results revealed different patterns in the emotional responses to the affective touch sounds compared to the object-based ones, although participants could not confidently identify affective touch. Furthermore, explicitly stating that the sounds involved object-based interactions increased the evoked valence of two specific object-based sounds. These findings highlight the importance of meaning in affective touch and reveal the high complexity of the sonification of touch. This study paves the way for future research on the emotions of auditory affective touch.**

***Index Terms*—Affective Touch, Skin, Sound, Audio, Emotions.**

I. Introduction

The tactile sensory modality, especially through affective touch, is crucial for human relationships, largely due to its role in emotional induction and communication. Affective touch can influence the emotions of both touchers and touchees [1]. For instance, affective touch can reduce stress [2], and it has been shown to have positive effects on the parasympathetic regulation of infants, whether it is delivered by the mother or the father [3]. In addition, affective touch can elicit positive emotional states, evidenced in autonomic nervous system responses, like pupil dilation [4]. When it comes to communication, individuals can recognize a wide variety of intentions and emotions through touch [5], [6]. Individuals have the ability to recognize, above chance, a broad variety of socio-emotional intentions (e.g., sympathy, calming, joy, gratitude, sadness, fear, anger, attention, and disgust) conveyed by a toucher hidden from sight [7], [8]. Moreover, romantically involved couples are additionally able to transmit envy, embarrassment, and pride [9]. However, as people's lives and ways of communicating have become increasingly digitalized with devices such as smartphones, virtual reality headsets, augmented reality goggles, and others [10], the sense of touch has been neglected. Crucially, touch deprivation has been shown to be associated with detrimental mental health effects such as higher anxiety [11], increased depression symptoms [12], and more generally, worse well-being (e.g., [13], [14]).

Against this background, the desire to incorporate tactile interactions into remote communication modes is expanding. The prominent approach thus far has revolved around providing haptic feedback through a broad variety of haptic interfaces, which has given rise to a large body of literature (e.g., [15]; see also [16], [17], for reviews). However, most of these technologies are not easily implementable, as they require additional (generally large) equipment, often including actuators and voice coils. This raises the need for an alternative way of conveying equivalent socio-affective cues that touch provides. Here, an interesting option lies in leveraging the possibility of transmitting the vibrations produced by touch behaviors through auditory signals. Interfaces taking advantage of this can be readily implemented with existing hardware and do not require major additional costs.

Sound and touch are closely related given that the vibrations produced by touch can be encoded via the somatosensory system [18] or and by the auditory system [19]. Scarce research has shown that the signals produced by the vibrations of interacting skins (recorded by means of accelerometers), can provide information on the velocity and pressure of the received touch [20]. Furthermore, de Lagarde et al. [21] started exploring the auditory recognition performance of stereotypical skin-on-skin touch gestures on a person's forearm recorded with a piezoelectric transducer. The sounds produced were subsequently used in a series of experiments, in which participants were tasked with categorizing the specific tactile gestures performed (i.e., stroking, rubbing, tapping, hitting) and their emotional intentions (i.e., anger, attention, fear, joy, love, sympathy). Their results showed that participants could recognize certain sounds and intentions with a probability above chance. This body of research highlights the unique acoustic properties of touch behaviors involving human skin and suggests promising avenues for further research. Nonetheless, important questions remain to be answered, such as the emotions that the affective touch sounds can elicit and the ability to differentiate them from other sounds.

The aim of the present research is to provide insights into the potential of affective touch sounds to elicit specific ranges of emotions and whether these differ from the emotions elicited by non-affective touch sounds. Furthermore, we aimed to explore the influence of context disambiguation pertaining to the nature of sounds on their evocation of emotions. A secondary objective of this study is to examine individuals' ability to identify affective touch sounds. Importantly, this research focuses on organic affective touch (i.e., naturally performed by a variety of couples in a romantic relationship), as opposed to stereotypical ones. As such, the gestures were bound to be performed at a velocity within the ideal range for affective touch by the specialized CT afferents. Hence, our method brings high ecological validity to this stream of research. To this end, two online studies were conducted. In Experiment 1, we evaluated the emotions elicited by 10 different organic affective touch sounds, together with five friction-based object-based sounds involving inanimate objects and the sound of crackling fire. In addition, we evaluated people's ability to determine whether the sounds involved affective touch or not. In Experiment 2, we assessed the influence of disambiguating the nature of the sounds on individuals' emotional responses.

II. Experiment 1: Emotional Responses and Affective Touch Identification

A. Participants

Participants in the two experiments reported here were recruited from Prolific (https://www.prolific.com/). They provided their consent electronically before beginning the experiments. The experiments were conducted in accordance with the Declaration of Helsinki. Experiment 1 had a median duration of 11.5 minutes, and participants received GBP 1.70 for their participation. A total of 300 native English speakers from the UK took part in the experiment. Given the high involvement required in the experiment, the data from nine participants was excluded, as they reported a level of engagement below or equal to five on a 9-point five scale. The final sample comprised 291 participants (145 females, 145 males, 1 non-binary), aged 19–60 years (M_{age} = 41.50 years, SD_{age} = 10.91).

B. Apparatus and Materials

The stimuli comprised short audio recordings (approximately 5 seconds) involving affective touch sounds, as well as object-based touch and non-touch sounds as controls. All the experimental stimuli can be found on OSF here. The affective touch sounds consisted of real, highly organic audio recordings of touch behaviors from real couples in a romantic relationship. To create the affective touch sounds, 14 couples were recruited through the INSEAD-Sorbonne University Behavioural Lab. During the recordings, they were first briefed on the aims of the study, given guidelines as to the procedure for the session, and given the space to ask questions. Then, they were asked to relax and spend a few minutes recalling the non-sexual touch behaviors they usually undertake in their everyday life as a couple for communication purposes or making their partner or themselves feel a certain way. Next, they were asked to describe and explain the objective and circumstances of each of these behaviors and to subsequently reproduce them. The sounds were recorded with a LEWITT LCT 540 S (LEWITT, Austria) low self-noise microphone on super cardioid mode. The recordings were postprocessed with the Noise Reduction feature in Audacity v. 3.7.1 (https://www.audacityteam.org/). We then selected the sounds with the highest auditory quality. The final set of affective touch stimuli comprised 10 sounds, namely arm stroking, head-scratching, hugging, comfort rubbing, hand fiddling, relaxed stroking, calm stroking, rubbing, face stroking, and a soft slap on the thigh.

The control sounds, henceforth called object-based, consisted of two skin-on-object (i.e., table stroking and cardboard scratching) and three object-on-object friction-based sounds (i.e., rubbing balloons, stroking cardboard, and stroking metal), as well as one non-friction-based sound (i.e., crackling fire) serving as a sanity check given its high dissimilarity with the affective and non-affective sounds. The crackling fire and the rubbing balloons sounds were obtained from SoundCloud (https://soundcloud.com/). The remaining sounds were performed organically by a person not involved in the study and processed similarly as the affective touch sounds.

C. Design, Procedure, and Measures

The experiment followed a single two-level factor (Sound category: affective touch vs. object-based) within-participant design. All participants were exposed to all the 16 sound stimuli. The experiment was programmed and conducted in Qualtrics (https://www.qualtrics.com/). Participants could only use a desktop or laptop to complete the study, and they were required to wear earphones/headphones.

After providing their consent, participants completed a sound calibration task, in which they listened to an audio clip of a female voice reiterating the sound calibration instructions and providing a specific word (i.e., "carbonation") they were to input in the next step. Participants were asked to set the volume of their system to the lowest level at which they could comfortably hear the audio clip. The sound check audio was created with a text-to-speech generator. Then, participants were presented with detailed instructions stating that they would listened to sounds that "may or may not involve affective touch (i.e., related to physical touch between people in a close relationship)." Subsequently, participants began the main part of the experiment, in which the sounds were presented randomly, one at a time. For each sound, participants first evaluated how each sound made them feel. They selected the single pair of emotion words that best matched their feelings from 12 pairs of emotion words spanning from the circumplex of core affect defined by valence (on the x-axis) and arousal (on the y-axis) proposed by Jaeger et al. [22]. Here, each pair of emotion words is located at every 30°. The circumplex is an effective way to operationalize the evaluation of emotional responses to stimuli, given its ease of use and affordance to extract the affective composition of the emotions. Then, participants evaluated the extent to which they believed each sound involved affective touch via a 9-point visual analog scale (VAS) from 1 (*Definitely NOT affective touch*) to 9

(*Definitely affective touch*). Afterwards, participants completed a set of demographic questions (i.e., age, gender, maximum level of education completed), and they evaluated their level of engagement in the study via a 9-point VAS from 1 (*Not at all*) to 9 (*Very much*). Finally, participants were debriefed on the aims of the study.

D. Data Analyses

To analyze the emotional responses to the different sound stimuli, the angles of participants' responses taking the emotion circumplex as a unit circle were first extracted. For instance, the *Happy, Satisfied*, *Active, Alert* , *Unhappy, Dissatisfied*, and *Passive, Quiet* emotion words are located at 0°, 90°, 180°, and 270°, respectively. Then, the corresponding valence and arousal values of each response were derived by computing the cosine and sine, respectively, of each angle. Subsequently, independent one-way ANOVAs on the extracted valence and arousal values, with sound stimulus as main effect and participant ID as random effect, were conducted. Next, Bonferroni-corrected pairwise comparisons were conducted.

Furthermore, to evaluate participants' ability to identify sounds involving affective touch from those that did not, a one-way ANOVA on the identification of affective touch score with sound category as main factor and sound stimulus and participant ID as random effects was first conducted. Next, to probe the identification of affective touch in the specific sounds, a one-way ANOVA on the belief of affective touch with sound stimulus as main factor and participant ID as a random effect was conducted. For both models, estimated marginal means were computed, and Bonferroni-corrected pairwise comparisons, in the case of significant effects, were performed.

E. Results

The analysis of the emotional responses to the different sound stimuli revealed a significant effect of sound stimulus on valence, $F(15, 4350) = 37.44$, $p = .001$, $\eta_p^2 = .11$, and on arousal, $F(15, 4350) = 43.41$, $p = .001$, $\eta_p^2 = .13$. Panel A in Fig. 1 presents the estimated marginal means of the evoked valence and arousal, along with 95% confidence intervals (CIs), of the different sound stimuli. The results revealed different clustering patterns in the emotional responses to affective touch sounds compared to the object-based ones. Except for the soft slap and the hand fiddling sounds, the affective touch sounds were relatively clustered together around the negative x-axis, spreading slightly toward the negative y-axis. That is, the affective sounds tended to evoke emotions with low levels of negative valence and low arousal. Only one affective touch sound (i.e., arm stroking) elicited positive valence, whereas three object-based sounds evoked positive valence (i.e., crackling fire, stroking table, stroking cardboard). The sounds elicited varying degrees of arousal, with stroking table, crackling fire, and hugging eliciting the lowest arousal and stroking cardboard, rubbing balloons, and soft slap eliciting the highest arousal.

When it comes to participants' ability to identify affective touch, the results failed to reveal a significant effect of sound category, $F(1,14) = 0.85$, $p = .371$, $\eta_p^2 = .06$. For neither of the sounds, the identification scores reached the midpoint of the scale. Even though participants correctly identify that the control sounds did not involve affective touch ($M = 3.45$), they did not accurately judge that the affective touch sounds were so ($M = 3.69$; $p = .356$). As for the identification of affective touch in the individual sounds, the results revealed a significant effect of sound stimulus on the identification of affective touch, $F(15, 4350) = 27.01$, $p < .001$, $\eta_p^2 = .09$. Panel B in Fig. 1 presents the estimated marginal means of affective touch identification for each sound stimulus. None of the identification scores for any of the specific sounds reached the midpoint of the scale, although there were marginal differences across specific sounds. Moreover, the scores of the object-based sounds were intermingled with the affective touch ones.

III. Experiment 2: Context Manipulation

A. Participants

Experiment 2 lasted a median of 5.5 minutes. Participants received GBP 0.90 in compensation. A total of 99 native English speakers from the UK participated in the experiment. The data from four participants was excluded, as they reported a level of engagement below or equal to five. The final sample comprised 95 participants (47 females, 47 males, 1 non-binary), aged 20–60 years ($M_{age} = 41.52$ years, $SD_{age} = 11.54$).

B. Apparatus and Materials

The stimuli comprised the same audio recordings as in Experiment 1, except for the crackling fire sound, as we wanted to exclude the most obvious non-affective touch sound given the experimental manipulation.

C. Design, Procedure, and Measures

Experiment 2 followed a 2 (Sound category: affective touch vs. object-based) × 2 (Context: affective touch vs. object-based) mixed design with sound category as within-participants factor and context as between-participants factor. All participants were exposed to the 15 sound stimuli and were randomly assigned to either of the context conditions. The experimental manipulation consisted of changing the stated nature of the sounds. That is, whether they were related to affective touch or to interaction with objects. To manipulate context, a statement regarding the nature of the sounds was added before the sound calibration task, which was also added to the detailed instructions later. Under the affective touch condition, the statements read that participants would hear different sounds involving affective touch, following the same definition as in Experiment 1. In the object-based condition, participants read that the sounds involved different objects. The procedure was similar to Experiment 1, except here, only the evaluation of evoked emotions was conducted.

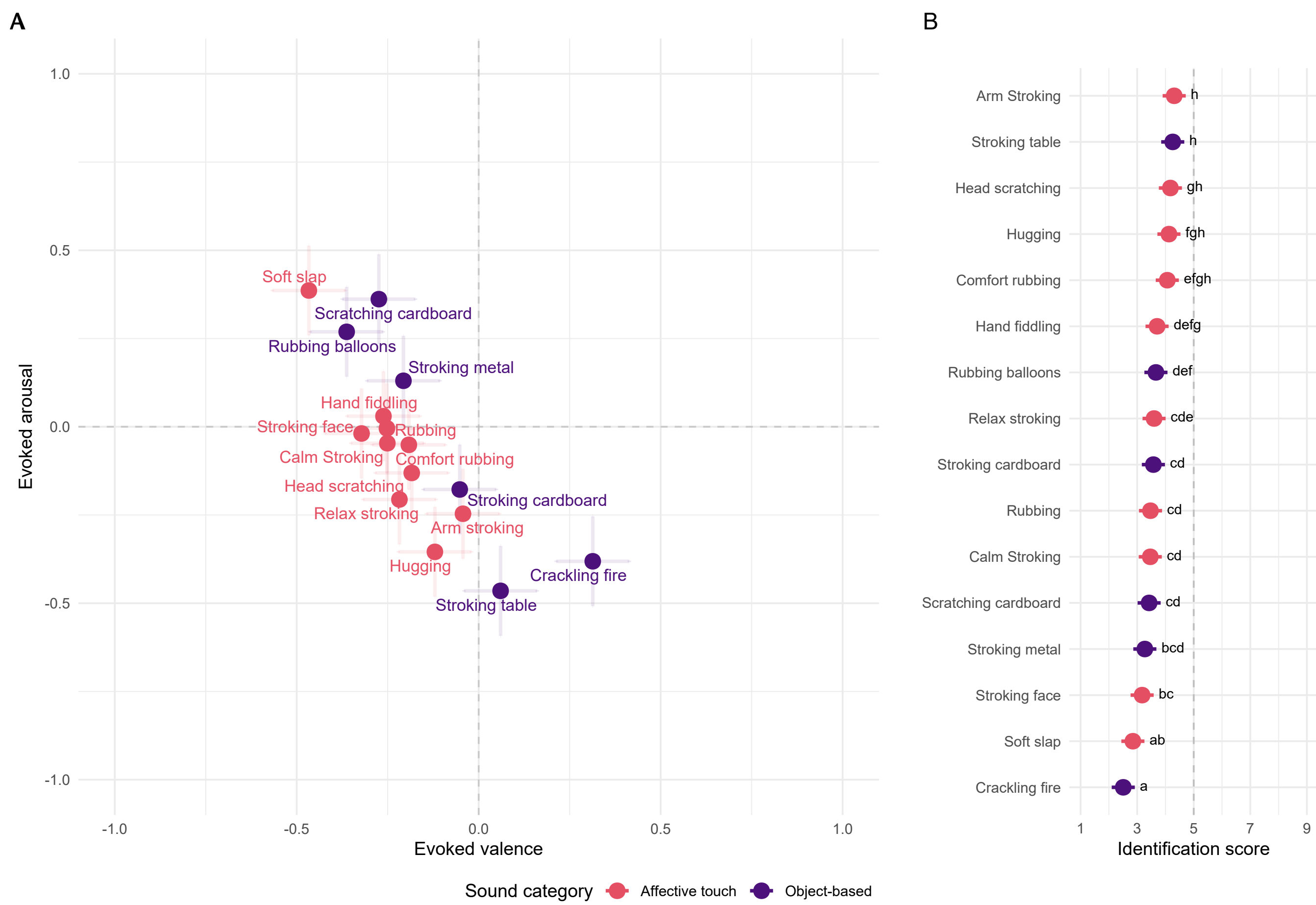

Fig. 1. (A) Emotional responses to the sound stimuli in Experiment 1, broken down by their evoked valence (x-axis) and arousal (y-axis); the values correspond to the estimated marginal means derived from the ANOVAs on the valence and arousal values extracted from participants' responses on the circumplex of emotion words; affective touch sounds are presented in **pink** and object-based touch sounds are in **violet**; the horizontal and vertical error bars correspond to the 95% CIs for valence and arousal, respectively. (B) Participants' identification of affective touch ability; the values correspond to the estimated marginal means from the ANOVA on participants' self-reported confidence in that the different sound stimuli involved affective touch, via a 9-point VAS from 1 (*Definitely NOT affective touch*) to 9 (*Definitely affective touch*); means sharing a letter are not significantly different at $p < .05$.

D. Data Analyses

To analyze the effect of context on the emotional responses to the sound stimuli, the valence and arousal loadings of participants' responses on the emotion circumplex were first extracted as in Experiment 1. Then, independent ANOVAs on the sine and cosine values with main and interaction effects of context and sound stimulus and participant ID as random effects were conducted. Then, estimated marginal means and Bonferroni-corrected pairwise comparisons were conducted.

E. Results

The results on evoked valence revealed only a significant main effect of sound stimulus, $F(14, 1302) = 5.98$, $p < .001$, $\eta_p^2 = .06$. There was no significant main effect of context, $F(1, 93) = 3.52$, $p = .064$, $\eta_p^2 = .04$, or a significant interaction effect of context and sound stimulus, $F(14, 1302) = 0.92$, $p = .541$, $\eta_p^2 < .01$. Examining the individual sounds, there were significant differences between the context conditions only in the table stroking and the cardboard stroking sounds (see Fig. 2). The table stroking sound evoked positively valenced emotions under the object-based context (M = 0.16), but it evoked negatively valenced emotions under the affective touch context (M = -0.12; $p = .023$). As for the cardboard stroking sound, it evoked marginally positive emotions under the object-based context (M = 0.02) but negatively valenced ones under the affective touch context (M = -0.27; $p = .016$).

As for evoked arousal, similar to the case of valence, the results revealed a significant main effect of sound stimulus, $F(14, 1302) = 19.52$, $p < .001$, $\eta_p^2 = .17$. The results also failed to reveal a significant main effect of context, $F(1, 93) = 1.10$, $p = .064$, $\eta_p^2 = .01$, or a significant interaction effect of context and sound stimulus, $F(14, 1302) = 1.13$, $p = .325$, $\eta_p^2 = .01$. In this case, there were no significant differences between the context conditions for any of the sounds.

IV. Discussion

The present research investigated the emotional influences of organic affective touch sounds compared to non-affective, object-based touch sounds. In Experiment 1, we found that even though participants could not confidently deduce whether

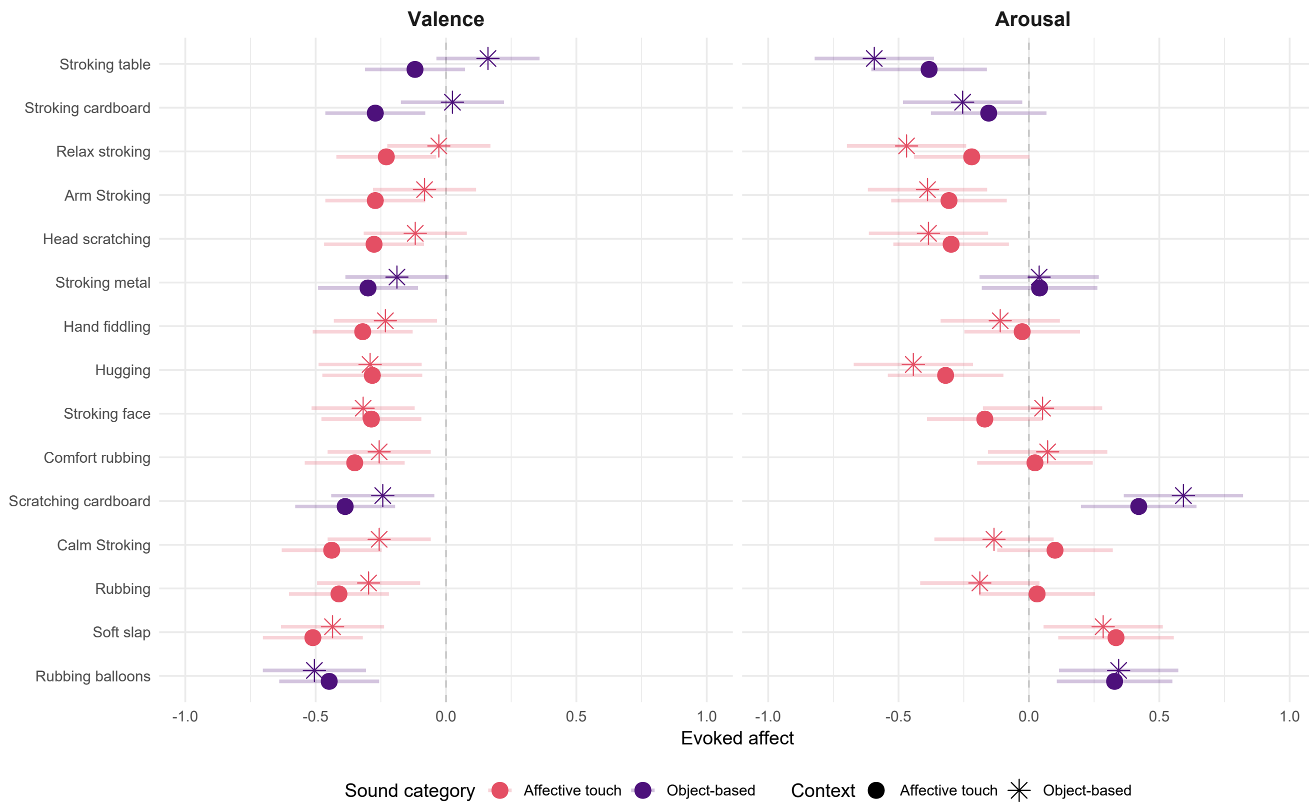

Fig. 2. Effect of context on the emotional responses to the sound stimuli in Experiment 2. The values correspond to the estimated marginal means from the ANOVAs on valence (left-hand side) and arousal (right-hand side) with the interaction and main effects of context and sound stimuli as main effect. The valence and arousal values were extracted from participants' responses on the circumplex of emotion words. Affective touch sounds are presented in **pink** and object-based touch sounds are in **violet**. Error bars correspond to the 95% CIs

specific sounds involved affective touch or not, different patterns in the emotional elicitation of affective touch sounds compared to object-based ones emerged. Contrary to our expectations, affective touch sounds evoked a range of emotions with varying degrees of negative valence and low arousal. On the other hand, except for the sound of crackling fire, which evoked positively valenced and low arousal emotions, object-based touch sounds evoked either slightly negative valence and substantially low arousal emotions or emotions with medium levels of valence and arousal. In Experiment 2, in which the nature of all the sounds, as either relating to affective touch or object-based interactions was specifically stated, congruence between the disclosed nature of the sounds and their actual nature rendered the elicited valence of object-based sounds more positive. However, this effect was only present in the table stroking and cardboard stroking sounds.

Even though the main objective of the present study was to assess the emotional responses to organic affective touch sounds, it is worth first examining participants' abilities to recognize affective touch in auditory cues. Individuals generally experience the sounds of affective touch co-occurring with haptic cues and often additionally with visual ones. It is possible that individuals were not able to identify affective touch in the different sounds due to limited experience hearing the auditory cues of affective touch in isolation. Furthermore, people may have highly idiosyncratic schemas and expectations as to what affective touch sounds like, which are likely not to match. Most people may expect skin-to-skin gestures to produce soft, subtle sounds given the softness and smoothness of the human skin. However, as past research has shown, human skin has a complex microscale topography characterized by creases and plateaus [23], that lead to the production of noticeable sounds, not unlike those produced by the interaction with smooth surfaces like paper [24]. Hence, despite some differences in the specific motions engaged in affective touch compared to non-affective touch, which is reflected in the rhythm and tempo of the auditory signals, these two categories of sounds are highly similar.

A crucial aspect to consider here is that affective touch is multidimensional, and it involves bottom-up and top-down levels of cognition [25]. Importantly, meaning that makes touch affective [26]. Indeed, the experience of touch is strongly influenced by a plethora of factors related to the person performing the touch (e.g., whether the person is a partner, a close friend, or a stranger, for example), as well as situational factors (e.g., what are the motivations and intentions behind the touch behaviors; [27]). Here, visual cues play a key role in providing meaning to affective touch, as they can more directly reveal the identity of the toucher and the context of the interaction [26], [28]. On the contrary, even though auditory cues alone can provide information about the low-level properties of surfaces being touched, especially in terms of their microgeometry (e.g., roughness; [29]), they provide little information as to the specific context of the touch actions and the identity of the parties involved. Considering this, given the lack of complementary cues that shed light on the nature and meaning of the sounds, coupled with the high level of similarity of friction-based sounds, it is difficult to deduce whether sounds involve affective touch.

When it comes to the emotions elicited by the different sounds used here, the ambiguity regarding the nature of sounds and the potential incongruence between participants' expectations of affective touch sounds and the actual sounds may have led to negatively valenced emotional responses. Past research has found that emotional reactions to naturalistic sounds are mainly driven by higher-order associations, as opposed to low-level acoustic properties, and that these reactions become more neutral when they are not cognitively accessible [30]. The results of the present study may be interpreted through the lens of schema congruency, which poses that moderate deviations from schemas trigger positive reactions but extreme deviations trigger negative ones [31], [32]. In the present study, specifically stating that the sounds involved object-based interactions led to a positive change in the emotional valence elicited by two object-based sounds (i.e., table stroking and cardboard stroking). Here, directly establishing the context of the sounds more in line with participants' expectations may have generated a large enough decrease in schema incongruency related to object-based touch gestures leading to a more positive perception of the sounds. These results highlight the importance of higher-order meaning in the emotional responses to auditory cues. Nevertheless, regarding the affective touch context, it is possible that people's schemas related to affective touch sounds were too strong to be changed by the experimental manipulation, and hence, incongruencies were not reduced. An intriguing point related to experience, meaning, and emotional responses worth examining here, is that positive associations to the sounds of organic affective touch sounds may be created experimentally. For instance, novel crossmodal associations can be created via mediated semantic and affective associative learning paradigms [33], [34].

Our research makes a number of contributions to the field of affective touch. To our knowledge, the present study is the first one investigating highly organic sounds of affective touch. We begin shedding light on individuals' ability, or lack thereof, to identify affective touch in sound stimuli. While, as with any scientific endeavor, further research is needed, it is worth considering these findings in developing future research on the sounds of affective touch and its potential contribution. That said, it may be tempting to continue exploring stereotypical sounds of touch [8] or more performative sounds, as they may be more easily recognizable. However, the ecological validity of such stimuli and the implications of using them in studying psychological processes should be taken into account.

Extant research has investigated the contributions of auditory cues on affective touch [35], such as the influence of the frequency of sounds produced by touch gestures on the perceived roughness of one's own skin (e.g., in the "parchment skin" illusion; [36]) and the perceived roughness of inanimate abrasive surfaces [37]. However, the ability of affective touch sounds to elicit emotions is still not well known. From a theoretical perspective, this research deepens our understanding of the multisensory nature of affective touch. Our results revealed that the auditory signals of positively valenced affective touch by themselves do not necessarily elicit positive emotional reactions. Our work adds to the literature on sound and affective touch by elucidating the complexity of the emotional responses to organic affective touch sounds and reiterates the importance of meaning in affective touch. Despite individuals' inability to confidently recognize affective touch sounds, we found different patterns in the emotions evoked by the affective touch sounds compared to the non-affective touch ones and that the emotional responses to the latter ones may be influenced by manipulating their context.

A. *Limitations*

Multiple limitations of the present research are worth pointing out. First, the use of sounds of organic affective touch, as opposed to stereotypical touch, was at the core of the present study, given that the aim was to obtain a high degree of ecological validity in this empirical investigation. However, the use of such sounds brings certain caveats. Given the highly idiosyncratic nature of affective touch, the number of possible touch gestures and their sounds is virtually endless. That said, we used a relatively large variety of sounds coming from 14 couples. An additional limitation arises from conducting the studies online, as despite having a sound calibration task, this limited the ability to exercise strict control over how participants experienced the sounds. Nevertheless, conducting the experiment online enabled having a large sample size. Moreover, while the evaluation of emotional reactions to the different sounds was based on an easy-to-use and validated measure that allows for a relatively high granularity of emotions and their affective loadings, they might not have precisely matched the emotions elicited by the sounds. A further limitation lies in the sample of participants, as the focus was on a single WEIRD (Western, Educated, Industrialized, Rich, and Democratic) country [38]. It is possible that other populations or cultures respond differently to the sounds and that their identification capabilities of affective touch sounds differ given that they may approach such behaviors differently. For instance, the sounds of affective touch may evoke more positive emotions in societies that exhibit closer physical contact.

Acknowledgments

This research was funded by the French ANR, project MATCH (ANR-22-CE33-0010), and Idex Sorbonne Université (11-IDEX-0004). We thank Hoai Huong Ngo, Germain Dépetasse, Jean-Yves Mariette, and Sébastien Robin, at the INSEAD-Sorbonne University Behavioural Lab, for their kind support in the recruitment of the couples and accommodations for the recording of the sound stimuli.

REFERENCES

[1] A. Schirmer, I. Croy, and S. R. Schweinberger, "Social touch — a tool rather than a signal," *Current Opinion in Behavioral Sciences*, vol. 44, p. 101100, Apr. 2022. https://doi.org/10.1016/j.cobeha.2021.101100

[2] I. Morrison, "Keep calm and cuddle on: Social touch as a stress buffer," *Adaptive Human Behavior and Physiology*, vol. 2, no. 4, pp. 344–362, Dec. 2016. https://doi.org/10.1007/s40750-016-0052-x

[3] M. Van Puyvelde, L. Collette, A.-S. Gorissen, N. Pattyn, and F. McGlone, "Infants autonomic cardio-respiratory responses to nurturing stroking touch delivered by the mother or the father," *Frontiers in Physiology*, vol. 10, p. 1117, Aug. 2019. https://doi.org/10.3389/fphys.2019.01117

[4] G. Bonino, A. Mazza, F. Capiotto, A. Berti, L. Pia, and O. Dal Monte, "Pupil dilation responds to the intrinsic social characteristics of affective touch," *Scientific Reports*, vol. 14, no. 1, p. 24297, Oct. 2024. https://doi.org/10.1038/s41598-024-74566-3

[5] B. App, D. N. McIntosh, C. L. Reed, and M. J. Hertenstein, "Nonverbal channel use in communication of emotion: How may depend on why." *Emotion*, vol. 11, no. 3, pp. 603–617, 2011. https://doi.org/10.1037/a0023164

[6] C. J. Cascio, D. Moore, and F. McGlone, "Social touch and human development," *Developmental Cognitive Neuroscience*, vol. 35, pp. 5–11, Feb. 2019. https://doi.org/10.1016/j.dcn.2018.04.009

[7] M. J. Hertenstein, R. Holmes, M. McCullough, and D. Keltner, "The communication of emotion via touch." *Emotion*, vol. 9, no. 4, pp. 566–573, 2009. https://doi.org/10.1037/a0016108

[8] S. McIntyre, S. C. Hauser, A. Kusztor, R. Boehme, A. Moungou, P. M. Isager, L. Homman, G. Novembre, S. S. Nagi, A. Israr, E. A. Lumpkin, F. Abnousi, G. J. Gerling, and H. Olausson, "The language of social touch is intuitive and quantifiable," *Psychological Science*, vol. 33, no. 9, pp. 1477–1494, 2022. https://doi.org/10.1177/09567976211059801

[9] E. H. Thompson and J. A. Hampton, "The effect of relationship status on communicating emotions through touch," *Cognition & Emotion*, vol. 25, no. 2, pp. 295–306, Feb. 2011. https://doi.org/10.1080/02699931.2010.492957

[10] C. Velasco, F. Reinoso-Carvalho, F. Barbosa Escobar, A. Gustafsson, and O. Petit, "Paradoxes, challenges, and opportunities in the context of ethical customer experience management," *Psychology & Marketing*, vol. 41, pp. 2506–2524, Jul. 2024. https://doi.org/10.1002/mar.22069

[11] K. Floyd, "Relational and health correlates of affection deprivation," *Western Journal of Communication*, vol. 78, no. 4, pp. 383–403, Jul. 2014. https://doi.org/10.1080/10570314.2014.927071

[12] N. Stein and M. Sanfilipo, "Depression and the wish to be held," *Journal of Clinical Psychology*, vol. 41, no. 1, pp. 3–9, Jan. 1985. https://doi.org/10.1002/1097-4679(198501)41:1⟨3::AID-JCLP2270410102⟩3.0.CO;2-M

[13] R. P. Rajkumar, "COVID-19 and mental health: A review of the existing literature," *Asian Journal of Psychiatry*, vol. 52, p. 102066, Aug. 2020. https://doi.org/10.1016/j.ajp.2020.102066

[14] M. Von Mohr, L. P. Kirsch, and A. Fotopoulou, "Social touch deprivation during COVID-19: effects on psychological wellbeing and craving interpersonal touch," *Royal Society Open Science*, vol. 8, no. 9, p. 210287, Sep. 2021. https://doi.org/10.1098/rsos.210287

[15] B. G. Sousa, S. Muthukumarana, R. Rosenkranz, M. E. Altinsoy, and S.-C. Li, "Evaluating affective touch generated via a shape-memory-alloy arm-sleeve by subjective report and facial muscle activity," *IEEE Transactions on Haptics*, pp. 1–8, 2024. https://doi.org/10.1109/TOH.2024.3502785

[16] A. A. Alsamarei and Bahar Şener, "Remote social touch framework: a way to communicate physical interactions across long distances," *Journal on Multimodal User Interfaces*, vol. 17, no. 2, pp. 79–104, Jun. 2023. https://doi.org/10.1007/s12193-023-00402-z

[17] E. Steinbach, M. Strese, M. Eid, X. Liu, A. Bhardwaj, Q. Liu, M. Al-Ja'Afreh, T. Mahmoodi, R. Hassen, A. El Saddik, and O. Holland, "Haptic codecs for the tactile internet," *Proceedings of the IEEE*, vol. 107, no. 2, pp. 447–470, Feb. 2019. https://doi.org/10.1109/JPROC.2018.2867835

[18] S. J. BensmaÏa and M. Hollins, "The vibrations of texture," *Somatosensory & Motor Research*, vol. 20, no. 1, pp. 33–43, Jan. 2003. https://doi.org/10.1080/0899022031000083825

[19] A. Akay, "Acoustics of friction," *The Journal of the Acoustical Society of America*, vol. 111, no. 4, pp. 1525–1548, Apr. 2002. https://doi.org/10.1121/1.1456514

[20] L. P. Kirsch, X. E. Job, M. Auvray, and V. Hayward, "Harnessing tactile waves to measure skin-to-skin interactions," *Behavior Research Methods*, vol. 53, no. 4, pp. 1469–1477, Aug. 2021. https://doi.org/10.3758/s13428-020-01492-3

[21] A. de Lagarde, C. Pelachaud, L. P. Kirsch, and M. Auvray, "Paving the way for social touch at a distance: Sonifying tactile interactions and their underlying emotions," *Proceedings of the National Academy of Sciences USA*, vol. 122, no. 19, p. e2407614122, 2025. https://doi.org/10.1073/pnas.2407614122

[22] S. R. Jaeger, C. M. Roigard, D. Jin, Y. Xia, F. Zhong, and D. I. Hedderley, "A single-response emotion word questionnaire for measuring product-related emotional associations inspired by a circumplex model of core affect: Method characterisation with an applied focus," *Food Quality and Preference*, vol. 83, p. 103805, Jul. 2020. https://doi.org/10.1016/j.foodqual.2019.103805

[23] J. G. Diosa, R. Moreno, E. L. Chica, J. A. Villarraga, and A. B. Tepole, "Changes in the three-dimensional microscale topography of human skin with aging impact its mechanical and tribological behavior," *PLOS ONE*, vol. 16, no. 7, p. e0241533, Jul. 2021. https://dx.plos.org/10.1371/journal.pone.0241533

[24] J.-F. Petiot, L. Fouere, A. Bigouret, A. Nkengne, S. Gagnaire, M. Thomas, and K. Vié, "Characterization of human skin properties with sounds. The music of the skin," in *16e Colloque National S-mart*, Karellis, France, Apr. 2019. https://hal.science/hal-02466623v1

[25] M. T. Fairhurst, F. McGlone, and I. Croy, "Affective touch: a communication channel for social exchange," *Current Opinion in Behavioral Sciences*, vol. 43, pp. 54–61, Feb. 2022. https://doi.org/10.1016/j.cobeha.2021.07.007

[26] U. Sailer and S. Leknes, "Meaning makes touch affective," *Current Opinion in Behavioral Sciences*, vol. 44, p. 101099, Apr. 2022. https://doi.org/10.1016/j.cobeha.2021.101099

[27] A. Saarinen, V. Harjunen, I. Jasinskaja-Lahti, I. P. Jääskeläinen, and N. Ravaja, "Social touch experience in different contexts: A review," *Neuroscience & Biobehavioral Reviews*, vol. 131, pp. 360–372, Dec. 2021. https://doi.org/10.1016/j.neubiorev.2021.09.027

[28] D.-M. Ellingsen, S. Leknes, G. Løseth, J. Wessberg, and H. Olausson, "The neurobiology shaping affective touch: Expectation, motivation, and meaning in the multisensory context," *Frontiers in Psychology*, vol. 6, p. 1986, Jan. 2016. https://doi.org/10.3389/fpsyg.2015.01986

[29] R. L. Klatzky and S. J. Lederman, "Multisensory texture perception," in *Multisensory object perception in the primate brain*, J. Kaiser and M. J. Naumer, Eds. New York, NY: Springer New York, 2010, pp. 211–230. https://doi.org/10.1007/978-1-4419-5615-6_12

[30] E. Asutay, D. V. S. Ll, A. T.-J. Nez, A. Genell, P. Bergman, and M. Kleiner, "Emoacoustics: A study of the psychoacoustical and psychological dimensions of emotional sound design," *J. Audio Eng. Soc.*, vol. 60, no. 37, 2012. https://doi.org/10.21437/PQS.2010-5

[31] J. Meyers-Levy and A. M. Tybout, "Schema congruity as a basis for product evaluation," *Journal of Consumer Research*, vol. 16, no. 1, p. 39, Jun. 1989. https://doi.org/10.1086/209192

[32] P. R. Zelazo, "Schema formation and stimulus–schema discrepancy: A basic unit and its properties." *Developmental Psychology*, vol. 60, no. 11, pp. 1978–1991, Nov. 2024. https://doi.org/10.1037/dev0001643

[33] F. Barbosa Escobar, C. Velasco, D. V. Byrne, and Q. J. Wang, "Assessing mechanisms behind crossmodal associations between visual textures and temperature concepts," *Journal of Experimental Psychology: Human Perception and Performance*, vol. 49, no. 6, pp. 923–947, 2023. https://doi.org/10.1037/xhp0001131

[34] F. Barbosa Escobar and Q. J. Wang, "Inducing novel sound–taste correspondences via an associative learning task," *Cognitive Science*, vol. 48, no. 3, p. e13421, Mar. 2024. https://doi.org/10.1111/cogs.13421

[35] C. Spence, "Multisensory contributions to affective touch," *Current Opinion in Behavioral Sciences*, vol. 43, pp. 40–45, Feb. 2022. https://doi.org/10.1016/j.cobeha.2021.08.003

[36] V. Jousmäki and R. Hari, "Parchment-skin illusion: sound-biased touch," *Current Biology*, vol. 8, no. 6, pp. R190–R191, Mar. 1998. https://doi.org/10.1016/S0960-9822(98)70120-4

[37] S. Guest, C. Catmur, D. Lloyd, and C. Spence, "Audiotactile interactions in roughness perception," *Experimental Brain Research*, vol. 146, no. 2, pp. 161–171, Sep. 2002. https://doi.org/10.1007/s00221-002-1164-z

[38] J. Henrich, S. J. Heine, and A. Norenzayan, "The weirdest people in the world?" *Behavioral and Brain Sciences*, vol. 33, no. 2-3, pp. 61–83, Jun. 2010. https://doi.org/10.1017/S0140525X0999152X