Textured materials can enhance tactile actuators for emotional expression and passive touch experiences

JUDITH WEDA, ANGELIKA MADER, MELISSA VAN SCHAIK, ADAM MEIJER, and DASHA KOLESNYK, University of Twente, The Netherlands
JAN VAN ERP, University of Twente, The Netherlands and TNO, The Netherlands

Social touch is an emotionally rich experience. When we mediate social touch through technology some of the tactile and emotional richness is lost because tactile actuators cannot display the full richness of human touch. We propose to add carefully designed textures to existing haptic actuators like vibration motors to enhance and intensify mediated touch experiences. Textures could be existing materials such as textiles varying in furriness or sandpaper varying in granularity. They could be designed by 3D-printing on textiles or by combining existing materials. When designing experiences where different tactile elements are combined it is important to know if any of these tactile elements have an inherent meaning, emotional or otherwise, and what happens to the emotional experience if the tactile elements are combined with other sensory modalities for instance in a video call or VR environment. We know that touch can intensify the emotional experience of other modalities. Therefore, if we want to build multimodal technology that facilitates rich emotional and social experiences we have to explore how material and dynamic factors of touch contribute to the emotional experience of that touch in unimodal as well as in multimodal systems. This research will lay a foundation for a future in which we can live emotionally rich experiences through mediated social touch.

CCS Concepts: • **Human-centered computing → Haptic devices**; *Ubiquitous and mobile devices*; • **Hardware → Haptic devices**; • **Applied computing → Psychology**.

Additional Key Words and Phrases: Haptics, Wearable, Texture, 3D-printing, Material enabling expression

ACM Reference Format:
Judith Weda, Angelika Mader, Melissa van Schaik, Adam Meijer, Dasha Kolesnyk, and Jan van Erp. 2023. Textured materials can enhance tactile actuators for emotional expression and passive touch experiences. In . ACM, New York, NY, USA, 4 pages. https://doi.org/XXXXXXX.XXXXXXX

1 INTRODUCTION

When mediating social touch with current technologies, some of the emotional richness of the touch is lost due to the limitations of current actuators. To mitigate this loss, current actuators for mediated social touch could be enhanced with designed textures or existing textured materials. We know that texture can evoke emotion when actively touched by the hands and when applied to the skin as passive touch [1, 2]. With added textures, a mediated vibration or pressure touch could come across as emotional or the inherent emotional experience of a specific touch could be more intense.

Textures can be presented by attaching them to haptic actuators in such a way that the texture is between the actuator and the skin. When the actuator is triggered its mechanical energy is transferred through the added texture. We expect that not only the texture but also the dynamic aspects of the actuation, such as speed and force, are relevant to the overall emotional experience

CHI' 23 Workshop - Body x Materials, April 23, Hamburg, Germany

ACM ISBN 978-x-xxxx-xxxx-x/YY/MM…$15.00
https://doi.org/XXXXXXX.XXXXXXX

of the touch. We are exploring what parameters of dynamic touch and texture touch contribute to the emotional experience of passive pressure touch as a whole.

Multiple questions arise surrounding the emotional experience of actuating textures, among these questions are the following:

(1) How do different dynamic and tactile/texture parameters contribute to the emotional experience of touch?
(2) Are the parameters that contribute to the emotional experience of touch the same for active and passive touch?
(3) To what degree does adding textured materials to touch influence the emotional experience of the touch?
(4) To what degree does textured touch contribute to the emotional experience when the touch is presented in a congruent multimodal context? (Or how do they influence each other?)

2 BACKGROUND

2.1 Inherent emotional meaning of touch

Touch carries rich emotional experiences, we think that a part of the emotional experience is inherent to the dynamic and texture parameters of the touch. In [5] we investigated if there is an inherent emotional meaning to dynamic touch parameters such as force, actuation speed, and stimulus width. We used a Check-All-That-Applies list with an emotional and sensory category and the Emojigrid [4]. We found that when applied to the forearm, force, and actuation speed carry an inherent emotional meaning. In [3] the authors explored multiple five touches by a haptic glove for two interaction scenarios with a clear emotional meaning, where in one study participants designed the social touch, and in a second the designed touches were validated. They found a relation between parameter levels and the type of emotion they conveyed. Supporting that there is an inherent meaning to touch parameters.

2.2 Evoking emotion with textured materials

Both actively exploring and passively being touched by texture can evoke emotion [1, 2]. Specific types of textures evoke different emotions when touched, for example: smooth textures are rated higher on pleasantness compared to surfaces [1]; soft materials are associated with happiness, rough textures with fear, anger and disgust, smooth textures were associated with sadness [2]. The results of [2] suggest that the association is not that clear-cut as non-rough textures like toy slime and plasticine were also associated with disgust and fear.

We found that participants were able to discern different emotions in a preliminary study where we explored emotions associated with 3D-printed textures [6], see Figures **??**, **??** and**??**. However, participants did not always agree with each other.

Textures can be identified by several characteristics that are on a continuous scale. For example, smoothness (or roughness) is a scale with extremes such as glass or gritted sandpaper on either side and many textures in between. Since smoothness and roughness are on different sides of the emotional scale according to the previous research we discussed, it would be necessary to find if there is a switch from positive to negative affect along the scale or whether the difference is due to other characteristics of the investigated materials.

2.3 Combining textural and dynamic aspects when designing haptic interaction

In [1] a difference in pleasantness between passively applied and actively explored textures was found. Namely, rough textures were considered more unpleasant when actively explored. This could be due to the differences between the glabrous and hairy skin and could imply a possible

interaction between other touch factors and the texture when it comes to the pleasantness of the touch experience.

We speculate that when it comes to communicating distinct emotion through texture, there is also an interaction between the different characteristics of texture such as compliance, smoothness and furriness. In addition, other tactile factors of the material, beyond texture, could influence the emotional experience of touch by the material. For example, the same material may evoke a different emotion when it is cold versus when it is warm.

When the same material is combined with haptic actuators, dynamic factors like actuation speed and force will also play a part in the emotional experience of the touch. How exactly dynamic factors interact with textural (and other material) factors to form a single emotional touch experience informs how we would need to design different emotional experiences for mediated social touch.

2.4 The importance of context in real life and multimodal systems

Context, in addition to the physical parameters of a touch, is key to interpreting the emotional meaning of social touch. Relationships, previous experiences, culture, and many other factors can colour the touch experience.

Context also plays a role when touch is mediated. In [3] the authors found that for certain touches there was a greater spread of clusters suggesting that outside context plays a bigger role for these specific touches. In [5] the arousal ratings of the stimuli were consistent between participants. Valence was rated less consistently. This suggests that while there is some inherent meaning to the parameters we investigated, part of the meaning is due to environmental context. In this case, participants invented their own context, as there was none presented to them during the study.

The emotional experience of mediated touch is due to the interaction of context, and physical touch parameters. How does this interaction work? Do context and touch parameters play an equal part or does one overwrite the other? This is important for the design of multimodal experiences (For example life, VR or AR experiences).

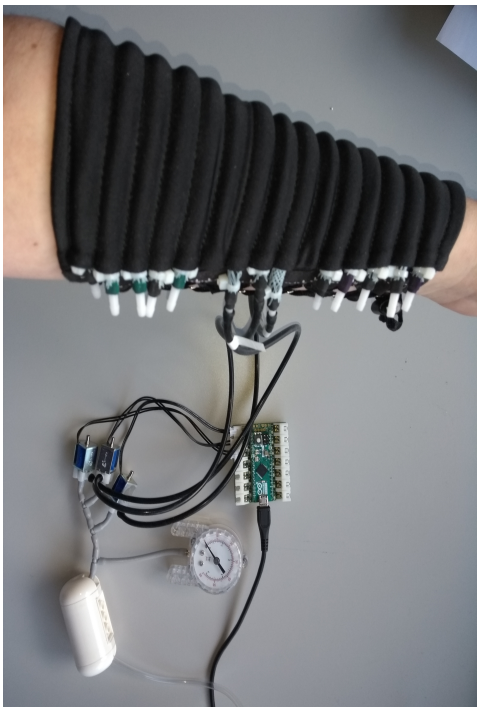
3 PROTOTYPE

We made several prototypes for mediating social touch. Namely, a McKibben sleeve, a motorized ribbon, and vibration sleeves. All these sleeves have potential to be combined with textures in different manners. Our main focus has been the McKibben sleeve, as it can present a pressure sensation to the wearer in such a manner that it can indent the texture into the skin in a movement perpendicular to the skin.

The McKibben sleeve, see Figure 1a, has 13 tunnels and the same number of McKibben actuators. A McKibben actuator is made of a mesh with a balloon inside. Air is blown into the balloon, when this happens the balloon cannot expand fully as it is constricted by the mesh. The pressure on the mesh cause the whole actuator to contract. When placed around the skin, this creates the sensation of a constricting pressure. The pressure can be comfortable or uncomfortable depending on the amount of pressure force in the pneumatic system.

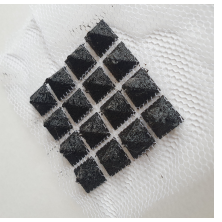
We designed two generations of 3D printed textures. Exploring in the first generation and following a more utilitarian approach for the second generation. Almost all textures were 3D-printed on textile so that they were flexible for easy actuation and placement around the arm, see Figures 1b and 1c for two examples of the first generation.

Existing texture like fur, leather, bubble plastic, sanding paper etc. can also be used to explore the effect of texture on the emotional experience of passive touch. See Figures 1d and 1e for two examples.



(a) The McKibben sleeve on the arm.

(b) Pointy texture 3D printed on textile with PLA, a non-compliant plastic.



(c) Pointy texture printed on textile with flexible TPU, a compliant material.

(d) A soft, fur texture.

(e) A putty texture.

Fig. 1. A McKibben sleeve and several textures designed to be used with the sleeve.

4 DISCUSSION POINTS AND CONCLUSION

Key questions need to be answered to design emotionally rich mediated touch experiences for the future. The following discussion points, addressing the questions presented in the introduction, can provide further insights into both the problem and solution:

(1) The inherent meaning of touch parameters (textural, material and dynamic) and how do they interact to form one emotional experience.
(2) Designing rich emotional experiences using textured tactile stimuli in the context of a multisensory mediated social experience.

REFERENCES

[1] Roberta Etzi, Charles Spence, and Alberto Gallace. 2014. Textures that we like to touch: An experimental study of aesthetic preferences for tactile stimuli. *Consciousness and cognition* 29 (2014), 178–188.
[2] Marina Iosifyan and Olga Korolkova. 2019. Emotions associated with different textures during touch. *Consciousness and cognition* 71 (2019), 79–85.
[3] Carine Rognon, Benjamin Stephens-Fripp, Jess Hartcher-O'Brien, Bob Rost, and Ali Israr. 2022. Linking haptic parameters to the emotional space for mediated social touch. *Frontiers in Computer Science* (2022), 50.
[4] Alexander Toet and Jan BF van Erp. 2020. The EmojiGrid as a rating tool for the affective appraisal of touch. *Plos one* 15, 9 (2020), e0237873.
[5] Judith Weda, Dasha Kolesnyk, Angelika Mader, and Jan van Erp. 2022. Experiencing touch by technology. In *Haptics: Science, Technology, Applications: 13th International Conference on Human Haptic Sensing and Touch Enabled Computer Applications, EuroHaptics 2022, Hamburg, Germany, May 22–25, 2022, Proceedings*. Springer, 110–118.
[6] Judith Weda, Melissa van Schaik, Dasha Kolesnyk, Angelika Mader, and Jan van Erp. 2022. Evoking Emotion In Mediated Social Touch Using 3D-Printed Textures On Textile. In *Poster presented at Society for Affective Science conference, Online.*