The Role of Temperature in the Study of Mindful Touch Perception

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Fig. 1. An illusion of multisensory experience, with an awareness of sensations and temperature.

CCS Concepts: • **Human-centered computing → Empirical studies in HCI**; **User studies**; **Empirical studies in interaction design**.

Additional Key Words and Phrases: Temperature, Touch, Mid-Air Haptics, Tactile Perception, Mindfulness Meditation, Tactile Experiences, Haptics

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1 INTRODUCTION

We sense the world not only by vision and sound but experiencing surrounding through all of our senses including (but not limited to) vision, sound, touch, smell and taste. Neither of these senses is isolated, they are as a whole as multisensory. Recent researches reveal that human can gain more enjoyment and be more impressive if multiple channels of their senses are activated [11].

Psychologists and neuroscientists have made significant contributions to the study of multisensory perception over the last fifty years [4, 5]. For instance, they have shed light on the multisensory interactions which arise from the (psychological) "flavour perception" [3, 14]. At the same time, the area had difficulties beyond the realm of audiovisual events and outside of laboratory settings because of the limited ability to provide and manipulate sensory stimuli [6].

Mindfulness meditation has been shown to affect our sense of perception, attention *etc.* [7–9, 12, 16]. Yet, in our daily life, we often take our senses - *e.g.* smell and temperature - for granted. We wonder what if we are more mindful of our senses, how would it change our perception and experiences. We conducted a study to investigate the effect of mindfulness meditation on mid-air touch perception, and observed that temperature is a crucial factor in this experience.

2 DESIGN SENSORY EXPERIENCES WITH TEMPERATURE CONTROL

Temperature plays a crucial role in human sensory perception, influencing our experiences and interactions with the environment. We have conducted an experiment that participants were given the task to recognize digits 0 to 9 drawn on their palms using a mid-air haptic device under two conditions - with and without prior mindfulness meditation.

During the pilot study, one participant's palm temperature was lower than 34.5 °C. The participant struggled to recognize the characters and sometimes couldn't even perceive the presence of the stimuli; confirming prior works observations [15] that skin temperature influences the tactile threshold. Therefore, we included an additional step in the main study to measure and ensure that the participants' palm skin temperature is between 35 °C and 37 °C.

Skin temperature of the palm region has been observed to influence recognition performance, though we did not exclusively study these temperature effects. It is well known from the literature [1] that skin temperature has an effect on tactile sensation thresholds which follows our observation from the pilot study. We believe that it is due to the fact that the sensation is affected before the recognition. In our study, we made sure that skin temperature is always between 35 °C and 37 °C by measuring the skin temperature of the left palm at the start, breaks, and end of the recognition task, in both baseline and mindfulness conditions. We, therefore, suggest that the palm's skin temperature should be considered before rendering the mid-air tactile patterns for recognition.

Temperature is an integral part of the touch sensation. Whether it's for discriminative or affective touch, temperature plays a crucial role in the perceived sensation. The information about an object being explored during the discriminative touch relies on how cold or warm the object is under exploration. The affective touch can be a more pleasant experience when the touch is delivered with body temperature rather than ambient temperature [2]. Temperature information is conveyed to the brain by slowly conducting unmyelinated type C neural fibres, unless the temperature is too high (above 45°C) or too low (below 15°C). Additionally, the pleasantness of touch is conveyed by slow-conducting type C fibers known as C-tactile fibers [13]. Simultaneously exciting these fibers gives users a more pleasant experience than stimulating only one. The temperature has been found to influence the threshold of perception [15]. Maintaining skin temperature at certain levels can improve touch perception. The reverse can also be tested, exploring the influence of touch on temperature perception.

3 CONCLUSION AND INPUT FOR DISCUSSION

In recent years, emerging technologies have changed our lives and made scenarios that used to be depicted in fiction or even fantasy now become part of our life, for instance, the buzzword Metaverse. The technology-enhanced multisensory experience is gaining attention in academia and industry. Vision and sound are the most common two sensory cues combined in experience. The revolution of immersive technology opens up new venues with breathtaking visualisation and surrounding sounds. Here we would like to discuss more on the sensory experience that we often overlook, such as temperature, smell, taste, *etc*,.

In the design of haptic displays during active hand-based interactions with virtual objects, the thermal feedback of objects (temperature) is an essential element to take into consideration. Therefore it is desirable to include thermal feedback stimulation to improve the realism in Virtual Reality using thermal displays [10]. Given the importance of temperature in touch perception, it is essential to consider the thermal feedback in various HCI applications such as affective remote touch, teleoperation, training, and other interactive simulations. We recommend that future studies further investigate the relationship between temperature and sensory perception to gain a more comprehensive understanding of its impact.

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