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Reliability of the thermal sensation threshold induced by the exposure to millimeter waves

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The use of millimeter wave expands further due to global spread of the fifth-generation wireless communication systems. Thermal effect is a dominant factor which potentially causes pain and tissue damage at the exposed body part to the millimeter wave (ICNIRP 2020). However, even the threshold of thermal sensation, the temperature at which the first subjective response to the thermal effects of the millimeter wave occurs,-remains unclear. Here, we proposed the method for measuring the thermal sensation threshold when exposed to the millimeter waves and investigated the reliability of the thermal sensation threshold.

Twenty healthy adults (4 female, mean age: 35.2 ± 5.0 years) were exposed to the millimeter waves at a frequency of 28 GHz delivered by a lens antenna at the fingertip of the left middle finger. The thermal sensation threshold was determined as the skin temperature at which thermal sensation was perceived when exposed to each of five levels of antenna input power: 0 W (sham), 1 W, 1.5 W, 2 W, and 3 W. This measurement session was repeated twice in the same day to evaluate the reliability of the perception threshold. The Bland-Altman analysis was performed to evaluate the absolute reliability, and the intraclass correlation coefficient (ICC) was used as a proxy for the relative reliability. The probability of perceiving the thermal sensation was also counted.

The mean of the thermal sensation threshold for each exposure condition ranged 35.4℃–36.0℃ (relative temperature change: 0.8℃–1.2℃). Bland-Altman analysis revealed no fixed or proportional bias. The ICC between sessions was “substantial” for the threshold with 3 W condition, whereas it was “moderate” to “slight” for those with the lower intensities (Figure 1). Similarly, all participants perceived a thermal sensation with 3 W condition in both sessions, whereas the probability of perception gradually decreased as the exposure level decreased from 2 to 1 W. Surprisingly, 7 and 6 out of 20 participants (65% in total) answered that they felt thermal sensation in both or one of the sessions with 0 W condition.

These results suggest that the reliability of thermal sensation perception depends largely on the exposed electrical power. Therefore, the reliability became reasonable when the electrical power was relatively high, which is likely to induce a rapid increase in skin temperature. However, the fact that many participants perceived illusory sensations even in the sham condition suggests that in general the perception of thermal sensation may be ambiguous presumably due to the nature of subjective experience.

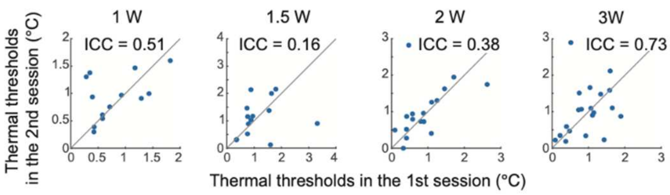

Figure 1. Scatterplots and the intraclass correlation coefficient values of thermal thresholds (relative temperature change) between two sessions in each exposure level.

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