

## Tickle sensation induced by hearing a sound<sup>1</sup>

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In the present study we report an illusion in which sound presented near to the head induces a tactile experience. We stroked the left ear of a dummy head with a paintbrush and recorded the sound and the scene. We then presented the sound, the images, or the both to participants. The participants rated their subjective tactile experience by answering a questionnaire. The results revealed that the participants felt a tickling sensation when the sound was presented near to the head, but not when it was presented distant from the head. Viewing the scene had little or no effect on the tactile impression. The results suggest that audiotactile interactions occur predominantly in a region immediately surrounding the head.

**Key words:** multisensory interactions; tickle sensation; auditory peripersonal space;

Imagine a mosquito is approaching your neck from your back. You probably notice it by its flying sound and might simultaneously feel itchy on the back of your neck. This example might imply the existence of audiotactile interactions occurred near the body. However, while visuotactile interactions in peripersonal space are now well-documented far fewer studies have attempted to examine audiotactile interactions in peripersonal space. In the present study we report an illusion in which only hearing a sound induces a subjective tactile experience.

### Methods

Fifty students participated in this experiment. Each participant was randomly assigned to one of five conditions: A-Near, AV-Near, A-Far, AV-Far, and V.

A microphone, which was inserted into the left ear of a dummy head, recorded the sound as we stroked the ear with a paintbrush, as if to tickle the ear (Figure 1a). The scene was also recorded on video-

tape. We presented either the sound (A condition), the images (V condition), or the both (AV condition) to the participants for 30 seconds. The sound was presented either through headphones (Near condition) or a loudspeaker placed at a distance of 80 cm from the participant's left ear (Far condition). The Leq sound level was measured at the left ear and set at 54 dB (A) for each condition. This level was almost the same as that of the actual stroke.

After the presentation of one of the five conditions the participants rated their agreement with each statement of a questionnaire on a 7-point scale ranging from totally disagree (1) to totally agree (7). The questionnaire included four statements (see Figure 1 b). Statements 1 and 2 related to our interest of whether a tactile impression was induced by the sound. Statement 3 was included to control for demand characteristics. Statement 4 was not included in the A condition. The sentences were presented one by one on a display in a random order.

### Results and Discussion

The mean ratings in the V condition were small overall, suggesting that viewing the scene of the tickling had little or no effect on the tactile impression. Because the mean ratings for all of the statements in the AV condition were not significantly different from those in the A condition, the data from the A and AV conditions were pooled so that we could assess the effect of the distance factor on the

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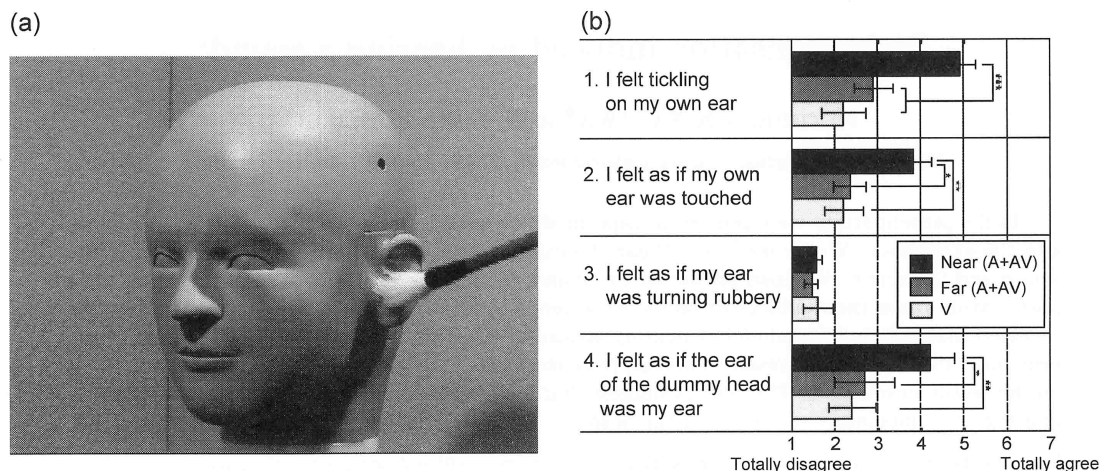


Figure 1. (a) A frame of the movie presented to the participants showing how we stroked the left ear of the dummy head with a brush. A microphone was inserted into the left ear and recorded the sound of the brush stroke. (b) Questionnaire results. Each bar indicates the mean rating of 20 participants (in the Near and Far conditions) or 10 participants (in the V condition) with standard errors. Significance values are indicated with asterisks (\*  $p < 0.1$ ; \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$ ; Tukey's HSD).

tactile impression (Figure 1b).

A two-way ANOVA of the rating data, with the between-participants factor of the presentation condition (Near, Far, and V) and the within-participants factor of the four statements, revealed significant main effects of the presentation condition [ $F(2, 47) = 6.06, p < 0.01$ ], and of the statements factor [ $F(3, 121) = 23.21, p < 0.001$ ]. There were also significant interaction between them [ $F(6, 121) = 4.56, p < 0.001$ ]. The participants in the Near condition responded more positively than the participants in the Far and V conditions to the statement 1. Similar trends were observed for the statements 2 and 4, but not for the statement 3 as expected. These results suggest that sound presented close to the head could induce a tactile impression, but sound presented at some distance from the head could not.

One may argue that imagery could be involved in the phenomenon. That is, when the participants heard the sound, they imagined a situation in which they were tickled by something and they in turn felt tickling on their ear. However none of the participants in the A condition was aware of what the sound was, and so they could not imagine such a situation. Therefore imagery cannot fully explain this illusion.

Our results suggest that a tickle sensation, that has to date been considered unique to the somatosensory system (e.g., Stein & Meredith, 1993), in fact can occur from hearing a sound delivered near to the head. Our results also provide support for the recent suggestion, based on psychophysical (Kitagawa, Zampini, & Spence, in press), neurophysiological (Graziano, Reiss, & Gross, 1999) and neuropsychological data (Farnè & Ladavas, 2002), that audiotactile spatial interactions occur predominantly in the region immediately surrounding the head (i.e., perihed space).

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