Voluntary movement influences the temporal perception of auditory-tactile

stimuli in temporal order judgment task

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Voluntary movement, which means the intentional movement to the outside world, affects the temporal perception in one's daily life. However, in prior works, how voluntary movements affect temporal perception of auditory-tactile stimuli didn't agree with each other, e.g. subjective simultaneity (PSS) and just noticeable difference (JND). PSS means the time point two stimuli are perceived as simultaneity and JND means temporal resolution of temporal order judgment (TOJ), in which a pair of stimuli is presented to participants with various stimulus onset asynchronies (SOAs).

Nishi et al [1] found that, compared to involuntary movement, voluntary movement significantly affected the PSS and improved the JND, whereas Frissen et al [2] found that the PSS of active and passive conditions is 12 ms and -45 ms, respectively, and active movement had no significant difference on the JND. It is already known that sound travels through air with 330 m/sec and arrives in brain with about 50 ms, and the feeling of being touched travels in a velocity of 55 m/sec. So, it is unintelligible that how did prior work with the same conditions and stimuli get divergent results. And also, these divergent results preclude the research on the mechanism of temporal perception affected by voluntary movement. A further complication is small differences in methods used by prior work, which might contaminate the results.

To resolve these discrepancies and methodological differences, we improved the methods of Nishi et al and focused on the effects on temporal perception in auditory and tactile stimuli induced by voluntary movement with TOJ task once more.

The TOJ task was performed in voluntary, involuntary, and no-movement conditions and participants were asked to answer which stimulus was first. The SOAs were ± 240 , ± 120 , ± 60 , ± 30 , and 0 ms (negative values indicated that tactile stimulus preceded auditory stimulus). There were ten participants (1 female and 9 males, mean age: 25 years) in present experiment.

Auditory stimulus and tactile stimulus were a sinusoidal wave sound by earphones and an impulse force both in 15 ms, then we counted the ratio of the answers for each SOA and used logistic regressions, a generalized linear model, to fit to the distribution of the mean TOJ data. PSS and JND values were calibrated with the regression analysis (Eq. (1) and (2)). A two-tailed t-test was used to examine the results of PSS and JND based on no-movement.

$$y = \frac{1}{\frac{(\alpha - x)}{1 + \varepsilon \beta}}$$
(1)

PSS =
$$\alpha$$
; JND = $\frac{x_{75} - x_{25}}{2} = \beta \log 3$ (2)

The JND based on no-movement condition is larger in voluntary condition than involuntary condition, which is inconsistent with previous studies where voluntary movement either improved the JND or had no effect on the JND in previous studies. Such divergent results might be caused by the methodological differences, which involved the learning and prediction bias [3], the moment of target onset [4], different voluntary movements, and well-trained participants.

The fact that the PSS based on no-movement in voluntary condition seemed similar with the results of Nishi et al compared to involuntary condition, but different with the results of Frissen et al, which presented that the PSS of active and passive conditions is 12 ms and -45 ms, respectively. These differences might be caused by different methods. Thus, this similarly significant shift of PSS in both studies strongly indicated that voluntary movement had a considerable effect on temporal simultaneous perception of auditory-tactile stimuli. So, the mechanism of effects on PSS by voluntary movement supposed by Nishi et al, was confirmed in present study once more.

In conclusion, our results showed that voluntary movement significantly affected the PSS, auditory stimulus should be presented much earlier than tactile stimulus, and impaired the JND, compared to involuntary movement. References

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