Effects of Sounds on Tactile Roughness Depend on the Congruency between Modalities

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\section*{INTRODUCTION}

\begin{itemize}
\item Sound feedback of touch-produced sounds modifies tactile roughness perception. (e.g., "Parchment-skin illusion": Josinaki & Hori, 1998)
\item Touching stimuli in synchrony with the intensity change of white noise decrease the slope (i.e., exponent) of tactile roughness estimation function. (Suzuki et al., 2008)
\end{itemize}

- White noise does not affect tactile length estimation.
- Pure tones do not modify both tactile roughness and length estimation.

\begin{itemize}
\item White noise (64 dB) modifies roughness perception of coarser surface (30, 40 \(\mu m\)) but it does not affect finer surface (3, 12 \(\mu m\)). (Suzuki & Gyoba, 2007)
\end{itemize}

\textbf{Question:} Do crossmodal effects likely occur in a limited range of tactile surfaces or in the appropriate combinations of information between modalities?

The present study investigated whether the crossmodal effects of sounds on tactile roughness depend on the congruency of information about roughness.

\section*{RESULTS}

The error rates were transformed to the arcsine and were analyzed separately for each of the coarse and fine pairs using a repeated-measures ANOVA with Sample (rough/smooth) \times Sound (loud sound/weak sound/no sound) as factors.

\begin{itemize}
\item Fine stimulus pair
\begin{itemize}
\item Significant Sample \times Sound interaction \((p < .05)\)
\item The error rate for the rough sample
\begin{itemize}
\item weak-sound > loud-sound
\item > no-sound
\end{itemize}
\end{itemize}
\item The rough sample was judged to be smoother when the weak (congruent) sound was presented than when the loud sound or no sound was presented.
\end{itemize}

\begin{itemize}
\item Coarse stimulus pair
\begin{itemize}
\item Significant Sample \times Sound interaction \((p < .001)\)
\item The error rate for the smooth sample
\begin{itemize}
\item loud-sound > weak-sound
\item > no-sound
\end{itemize}
\end{itemize}
\item Significant simple main effect of the Sample
\begin{itemize}
\item The error rate in the loud-sound condition \((p < .001)\)
\item smooth sample > rough sample
\item The error rate in the weak-sound condition \((p < .001)\)
\item rough sample > smooth sample
\end{itemize}
\item The loud (congruent) sound led the tactile roughness of the smooth sample to be perceived as rougher.
\item The weak sound modified the roughness discrimination toward the smoother direction.
\end{itemize}

\section*{METHOD}

Preliminarily, participants who did not participated in the main experiment conducted crossmodal matching of the roughness between abrasive paper and white noise.

The participants (N=12) touched the abrasive paper with the index finger back and forth.

The task was to discriminate the presented sample as either the rougher or smoother one of the pair, regardless of the sounds.

Sounds/no sounds were presented in synchrony with the hand movements.

The fine and coarse pairs were presented in separate sessions.

\section*{DISCUSSION}

\begin{itemize}
\item The effects of sounds on tactile roughness perception depend on the crossmodal congruency of information about roughness.
\begin{itemize}
\item The loud sound (congruent with the coarse texture) modified the perceived roughness of coarse stimuli toward the rougher direction.
\item The weak sound (congruent with the fine texture) decreased the roughness of both coarse and fine textures.
\end{itemize}
\item The louder sounds do not always affect the tactile roughness perception greater than the weaker sounds.
\end{itemize}

The intensity information included in sounds rather than the presence of sounds themselves affected the tactile texture perception.

\begin{itemize}
\item \textbf{Weak Noise} Leads to the perception of a smoother surface.
\item \textbf{Loud Noise} Leads to the perception of a rougher surface.
\end{itemize}

\begin{itemize}
\item Sounds have greater effects when roughness information is congruent between auditory and tactile modalities.
\end{itemize}

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