Auditory influence on tactile perception changes with age

Simon P. Landry*, Jean-Paul Guillecot and Francois Champoux

*Corresponding author's address: École d'orthophonie et d'audiologie, Université de Montréal, 7077 avenue du Parc, Montréal, H3N 1X7, Québec, Canada, simon.landry.4@umontreal.ca

Characteristics of auditory interaction with vision have been extensively studied. However, auditory system integration with other sensory modalities, such as the tactile system, lacks such thorough investigations. The objective of this study was to examine the effects of age on audiotactile integration in humans. Thirty-one participants between the ages of 20 and 65 were divided into three groups according to their age. Audiotactile integration was assessed using the "auditory flash illusion" in which 1, 2, 3, or 4 tactile stimuli were accompanied with 0, 1, 2, 3 or 4 auditory stimuli. Participants were asked to ignore auditory stimulations and report the number of tactile stimulations perceived. All participants were tested with task relevant auditory and tactile stimuli as a control measures and were shown to have similar abilities. However, groups differed during the experimental conditions. The youngest group reported a greater number of tactile stimuli than actually presented during the illusory experimental conditions. Participants in the middle and older age groups did not report this illusory tactile perception. These results suggest that age reduces predisposition to audiotactile integration. These results are consistent with developmental studies for multisensory integration in other sensory modalities.

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INTRODUCTION

Sensory stimulation rarely comes exclusively from a single modality, but rather from multiple modalities through multisensory stimulation (Driver & Spence, 2000). The synthesis of sensory input from various modalities is called multisensory integration (Stein & Stanford, 2008). Behavioral advantages due to multisensory integration include reduced sensory ambiguity (Green & Angelaki, 2010), increased reaction time (Giray & Ulrich, 1993), and enhanced localization ability (Schröger & Widmann, 1998). As of yet, most multisensory studies have focused on audiovisual integration. As such, the characteristics of auditory interaction with vision have been extensively studied during adulthood. For instance, some results suggested that older adults have quicker response times than younger adults in audiovisually congruent perceptual conditions (Peiffer et al., 2007). Older adults are also better at integrating or segregating audiovisual information in the context of incongruent information (Hugenschmidt et al., 2009). However, auditory system interaction with other sensory modalities, such as the tactile system, still lacks thorough developmental investigations. As of yet, no study exists to detail audiotactile interaction capabilities through adulthood. The objective of this study is to examine the effects of age on this multisensory interaction process in humans.

METHOD

Participants

Thirty-one participants were involved in the study. As in similar studies investigating cognitive or perceptual changes across the lifespan (e.g. Baxendale et al., 2010), participants were divided into three groups based on age (group 1: 18 to 30 years old, n=12; group 2: 31 to 45 years old, n=9; group 3: 46 to 65 years old, n=10). The groups were comparable with respect to their educational background and occupational status. All participants had relevant auditory thresholds tested (i.e. 1000Hz and 2100Hz) and found to be within normal limits (30 dB HL or less). The Research Ethics Board of the Université de Montréal approved the study and all the participants provided written informed consent.

Procedure, stimuli, and design

The stimuli and procedure used for the experimental condition were identical to the one used previously by Hötting & Röder (2004). Participants were instructed to report the number of tactile stimuli on a computer running a custom cognitive evaluation program on PsyScope software. Participants sat in front of a computer running the custom cognitive evaluation program and had their index finger placed on a tactile stimulator. The index of the dominant hand was stimulated for every participant. Background noise (70 dB SPL) was generated using a white-noise generator in order to mask any auditory hints emanating from the tactile stimulator. Before the experiment, participants were asked if they were able to guess the number of tactile stimuli without having their finger on the tactile device. This pre-evaluation precaution was taken to ensure that participants could not hear any auditory hints produced by the tactile device. Tactile stimulations were delivered at a suprathreshold level for each participant using a bone conduction transducer (Madsen Electronics 03204, Otometrics, Taastrup, Denmark). Auditory stimulations were delivered via attenuating circumaural headphones (10 S/DC, David Clark, Worcester, MA, USA) at a comfortable level (60-70 dB HL) for all participants. Ten trial types were presented twenty-five times in random order. Trials consisting of one tactile stimulus were paired with 0, 1, 2, 3 or 4 auditory stimuli. Trials with two tactile stimuli were paired with 0, 1 or 2 auditory stimuli. Trials of 3 and 4 tactile stimuli were paired with 0 or 1 auditory stimulus. Trials with two auditory and two tactile stimulations were used as filler trials. A total of 300 trial presentations were performed over five blocks of sixty random trial types. Trials consisted of short auditory stimulations (2100 Hz, 10 ms) presented simultaneously with tactile stimulations (1000 Hz, 50 ms). Auditory stimulations were delivered at intervals of 100 ms, while tactile stimulations were delivered at intervals of 200 ms. As per Hötting and Röder (2004), the first auditory stimulation preceded the first tactile stimulation by 25 ms. Participants were instructed to ignore auditory stimuli and to report the number of tactile stimuli on a computer by pressing the number 1, 2, 3 or 4 on a keyboard with their non-dominant hand.

An additional task was conducted in which an auditory discrimination task was used to ensure that all participants were able to discriminate the number of auditory stimuli presented successively. Trials consisting of 1, 2, 3 or 4 auditory stimuli (2100 Hz, 10 ms) were presented 10 times in random order with an interval of 100 ms between auditory stimuli. Auditory stimulations were delivered via headphones using the same procedure described...
earlier in the audiotactile experimental condition. To simulate the same aural environment as the experimental task (see previous task), a white-noise generator was used during the control condition. Participants were instructed to report the number of auditory stimuli on a computer running a custom cognitive evaluation program on PsyScope software.

**RESULTS**

The ability to accurately identify the correct number of auditory stimuli with no tactile stimuli present was similar across all groups. An analysis of variance with group (group 1; group 2; group 3) as a between-subjects factor and trial-type (1 auditory – 0 tactile; 2 auditory – 0 tactile; 3 auditory – 0 tactile; 4 auditory – 0 tactile) as a within-subjects factor was conducted. The analysis revealed that all groups were able to discriminate between differing numbers of auditory stimuli and that the main effect of the number of auditory stimuli was significant ($F(3, 84) = 26485.564, p < 0.001, \eta_p^2 = .999$). As expected, there was no main effect for groups ($F(2, 28) = 1.565, p = 0.227, \eta_p^2 = .101$) and the interaction between factors was not significant ($F(6, 84) = 1.705, p = 0.130, \eta_p^2 = .109$). The ability to accurately identify the number of tactile stimuli with no auditory stimuli present was also similar across all groups. An analysis of variance with group (group 1; group 2; group 3) as a between-subjects factor and trial-type (0 auditory – 1 tactile; 0 auditory – 2 tactile; 0 auditory – 3 tactile; 0 auditory – 4 tactile) as a within-subjects factor was conducted. The analysis revealed that all groups were able to discriminate between differing numbers of tactile stimuli and that the main effect of the number of tactile stimuli was significant ($F(3, 84) = 1485.694, p < 0.001, \eta_p^2 = .982$). Again, there was no main effect for groups ($F(2, 28) = 1.725, p = 0.197, \eta_p^2 = .110$) and, most notably, the interaction between factors was not significant ($F(6, 84) = 1.969, p = 0.079, \eta_p^2 = .123$).

All participants were clearly able to perceive the correct number of auditory-only or tactile-only stimuli presented, yet data suggest that older individuals were far less predisposed to perceive an illusory change in tactile perception compared to younger individuals in incongruent audiotactile conditions. Indeed, despite the similar ability to discriminate correct numbers of auditory or tactile stimuli in the congruent conditions (see results above). We found a significant relationship between age and performance in the incongruent audiotactile conditions when two ($r(31) = -.538, p = 0.079$), three ($r(31) = -.488, p = 0.005$), or four ($r(31) = -.475, p = 0.007$), auditory stimuli were presented with one tactile stimulus.

**CONCLUSION**

While the effect of age on audiovisual interaction has garnered attention, the effect of age on multisensory interaction for other modalities such as audiotactile have been, as of yet, ignored. Here, we present results suggesting a relationship between age and audiotactile capability. Consistent with previous developmental studies of audiovisual integration, the data reported here suggests an increase in multisensory segregation capability with age.

**REFERENCES**


