Extending the temporal principle of multisensory integration: A psychophysical and EEG investigation of cross-modal acoustic and vibrotactile amplitude modulation

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Declarations

STATEMENT OF ORIGINALITY

I hereby certify that the work embodied in the thesis is my own work, conducted under normal supervision. The thesis contains no material which has been accepted, or is being examined, for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made. I give consent to the final version of my thesis being made available worldwide when deposited in the University's Digital Repository, subject to the provisions of the Copyright Act 1968 and any approved embargo.

Justin Timora

ACKNOWLEDGMENT OF AUTHORSHIP

I hereby certify that the work embodied in this thesis contains published paper/s/scholarly work of which I am a joint author. I have included as part of the thesis a written declaration endorsed in writing by my supervisor, attesting to my contribution to the joint publication/s/scholarly work.

By signing below I confirm that Justin contributed by leading the development of the research design and methodology, data collection and analysis, and writing to the paper/ publication entitled “Steady-state EEG and psychophysical measures of multisensory integration to cross-modally synchronous and asynchronous acoustic and vibrotactile amplitude modulation rate”.

Dr Bill Budd

Candidature Research Outcomes

Publications

Timora, J. R., & Budd, T. W. (2018). Steady-state EEG and psychophysical measures of multisensory integration to cross-modally synchronous and asynchronous acoustic and vibrotactile amplitude modulation rate. *Multisensory Research*, 31(5), 391-418.

Conference Proceedings

Oral Presentations

Timora, J.R., & Budd, T.W. (2014). A Psychophysical and EEG Investigation of Cross-Modal Amplitude Modulation. Presented at the Australasian Experimental Psychology Conference 2014, 26 – 28 Nov, Coffs Harbour. doi: 10.3389/conf.fnhum.2014.216.00008.

Poster Presentations

Timora, J. R., & Budd, T. W. (2016, June). The influence of cross-modal temporal correspondence of amplitude modulation rate on EEG steady-state activity and perceptual sensitivity of simultaneous auditory and tactile stimulation. Presented at the International Multisensory Research Forum 2016, 15 - 18 June, Suzhou, China.

Timora, J. R., & Budd, T. W. (2015, April). Cross-modal phase influences the steady-state EEG response and perceptual sensitivity to amplitude modulated auditory and vibrotactile stimulation. Presented at the Australasian Experimental Psychology Conference 2015, 2 - 4 Dec Sydney.

Timora, J. R. & T.W. Budd (2014). Do Cross-Modal Phase Differences between Acoustic and Vibrotactile AM Stimuli Influence Audio-Tactile Integration? A Psychophysical and EEG Investigation. Presented at the International Conference on Cognitive Neuroscience, Brisbane, 27 -31 July. doi: 10.3389/conf.fnhum.2015.217.0037.

Timora, J.R., & Budd, T.W. (2013). Cross-Modal Modulation Masking: A Psychophysical and EEG Investigation of Simultaneous Acoustic and Vibrotactile Amplitude Modulation. Presented at the Australasian Experimental Psychology Conference 2013, 20 – 22 Nov, Wollongong. doi: 10.3389/conf.fnhum.2013.213.00006.

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"All I ever needed was something I can hold in my hands. And here it is"

– The Smith Street Band.

Contents

Abstract

The major aim of the current thesis was to examine whether the *temporal principle* of multisensory integration could be extended to include the cross-modal temporal congruence of other stimulus features. According to the temporal principle, cross-modal synchrony between the onsets of multisensory stimuli is fundamental to the binding of multisensory information, or multisensory integration. The examination of other temporal features in multisensory contexts remains limited. Amplitude modulation (AM) has an analogous influence on auditory and vibrotactile sensory processing and perception. This cross-modal dependence of the auditory and tactile modalities on temporal processing potentially facilitates multisensory integration. However, the role of this temporal feature in auditory and vibrotactile multisensory integration remains unexplored.

Psychophysical studies show that both auditory and vibrotactile sensitivity varies as a function of AM rate. Electroencephalography (EEG) research shows that the steady-state response (SSR), a sensitive measure of entrained oscillatory mechanisms, is also sensitive to AM rate. It has been proposed that the SSR reflects oscillatory activity with a functional role in the perceptual analysis of the temporal features of sensory stimulation. Subsequently, the SSR may be a potentially important EEG measure for multisensory integration, as recent theories propose that entrained oscillatory activity provides a flexible and dynamic mechanism for multisensory integration. It currently remains unknown as to whether the entrained oscillatory activity underlying the SSR also plays a vital role in auditory and tactile multisensory integration.

Across four separate studies, the current thesis investigates how the cross-modal temporal congruence between auditory and vibrotactile stimuli influences perceptual sensitivity, SSR activity and the potential relationship between them. Taken together, findings from the current thesis propose that the cross-modal temporal congruence of

temporal features, beyond stimulus onset synchrony, can dramatically influence perceptual sensitivity and the SSR. However, little evidence was found to suggest that the temporal principle extends to acoustic and vibrotactile amplitude modulation congruence.

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