Pip-and-flip?
Uncertainty factors the modulation of visuospatial attention on hearing

LiveMEEG 2020 Group C

F Cervantes Constantino, T Sánchez-Costa, G A Cipriani, A Carboni
Facultad de Psicología, Universidad de la República - Uruguay

Summary findings

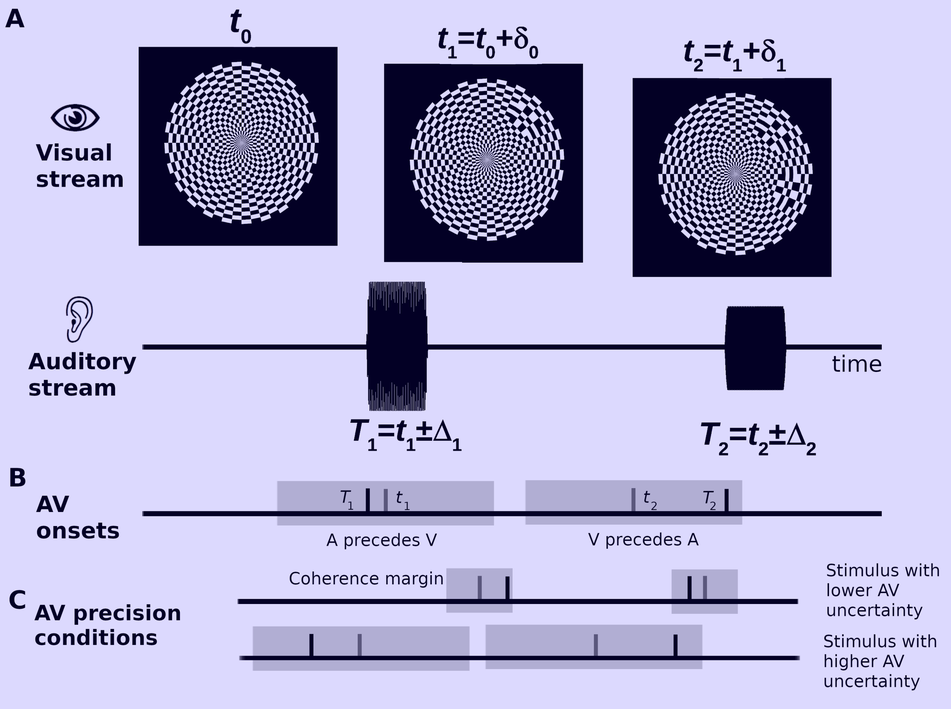
It has been proposed that attentional selection operates under a 'weighing' by precision scheme, with some experimental evidence [1,2].
In an audiovisual (AV) display, the ability of temporal uncertainty to influence cross-modal transfer of attentional biases was tested.
Uncertainty in the leading unimodal input from non-simultaneous streams influences such transfer effects.

Background

→ Computational bases for selective attention remain unclear. A proposal from the predictive coding literature is that attentional selection is subject to uncertainty estimation [3,4].
→ Temporal uncertainty in asynchronous audio and visual streams is a key variable for AV binding and perception [5-7].
→ Neural encoding of auditory input can be addressed in electroencephalography (EEG) through the tempotal response function (TRF) model of the auditory response [8].

Do TRF models inform of differential encoding of sound under visuospatial attention selection? Does precision favor changes to encoding?

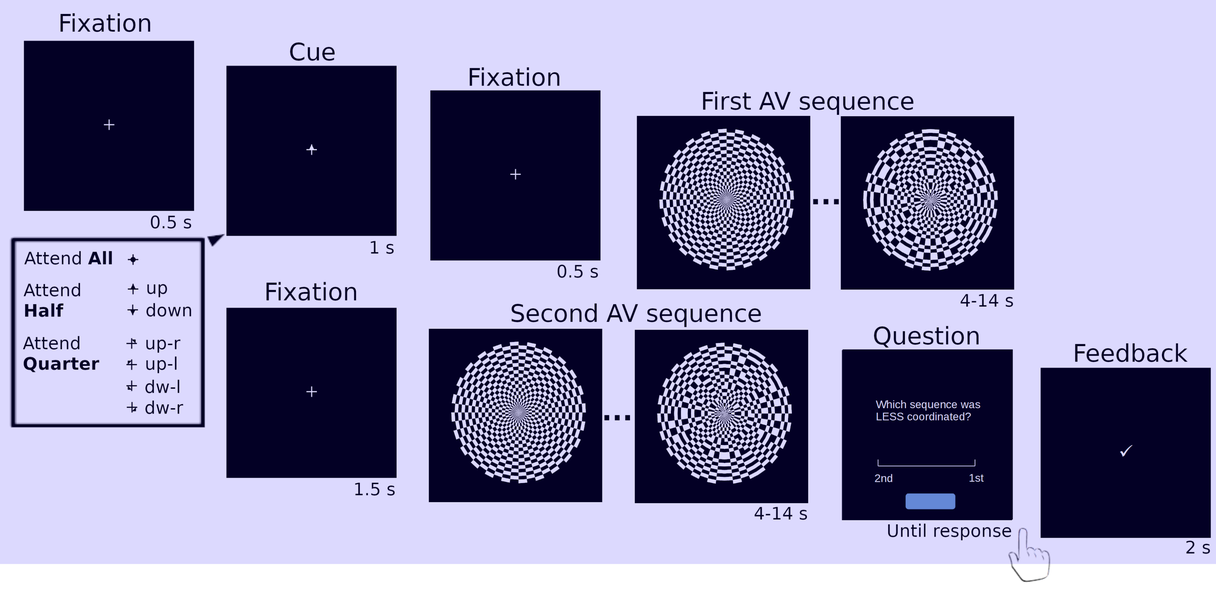
Methods



→ 30 participants asked to attend to specific sectors of the dartboard, in a AV uncertainty comparison task under EEG.
→ A first AV sequence was shown, followed by a second one. Participants compared between AV uncertainties across both sequences.
→ Relevant AV events were only within the indicated visuospatial sector (attend to All sectors, to a Half of the dartboard, or to a Quarter).

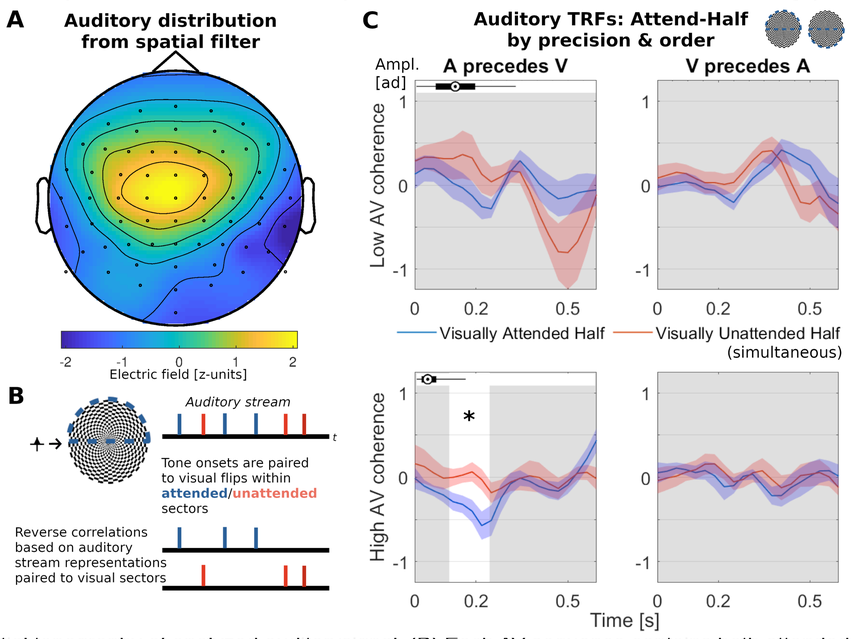
TRF analyses for **Attend-Half** (**AH**) and **Attend-Quarter** (**AQ**) conditions

→ Dynamic visual dartboards constructed with local visual contrast changes (flips, 60 locations).
→ Individual flips are paired with brief single tone pips of fixed duration (0.1-5 Khz range, 15 frequencies).
→ Probabilistic A-V onset asynchrony, uniformly distributed. Controlled range:
Lowest AV precision: ±330 ms asynchrony margin (weak AV association)
Highest AV precision: ±33 ms
Auditory onsets precede or succeed visual ones.
→ Each stimulus sequence has fixed AV temporal uncertainty (precision) level



Results

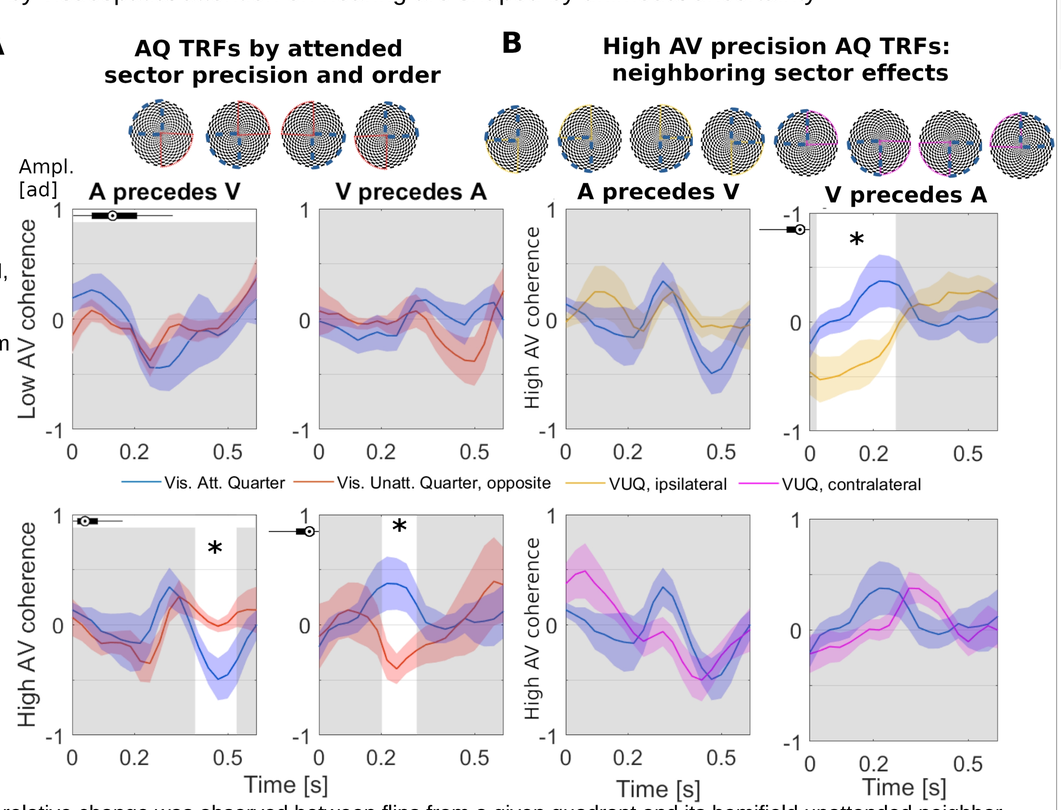
1. Higher AV precision enables visuospatial attentional modulations on auditory processing



(A) Spatial topography of analyzed auditorysignal. (B) Each AV sequence contains both attended and unattended visual domains. These are each associated to distinct tones in the continuous auditory stream. For TRF estimation, the auditory stream is partitioned accordingly. (C) TRF results for AH show no evidence of visual spatial attention-induced changes to auditory processing under low AV precision conditions (top, *onset asynchrony distribution shown in inset*). Under high AV precision (median shift 39 ms, bottom), visual processing may modulate ongoing associated tone processing.

2. Cross-modal modulations by visuospatial attention on hearing are shaped by unimodal uncertainty

(A) In AQ conditions and under high AV precision, TRF estimates show differential encoding of tones associated to attended versus opposite quadrants by visuospatial attention (bottom). In contrast to AH, this includes cases where visual onsets lead tone processing (bottom right). Insets indicate temporal distributions of visual onsets in the attended sector.
(B) TRF estimate comparisons between attended and neighboring quadrants to address selectivity effects. Left: For tones preceding corresponding visual onsets, no relative change by visuospatial attention was found at either ipsilateral or contralateral quadrant comparisons. Right: For tones that follow corresponding visual onsets, relative change was observed between flips from a given quadrant and its hemifield unattended neighbor. As in the previous Figure, only attended sector TRF sets are ordered by AV precision.



Discussion

→ Temporally precise margins between auditory and visual streams enable transfer of selective biases from visual attention onto hearing, as predicted for multimodal integration.
→ Unimodal uncertainty sources, arising in non-synchronous presentations, hierarchically shape cross-modal interactions, consistent with precision as a factor for attentional selection.
-For pips preceding flips: uncertainty relates whether pips may pair with the visually attended sector. AH conditions have such lower auditory uncertainty, which led to transfer effects observed relatively earlier than at AQ and more consistent with that detection mechanisms instantiated from the initial bottom-up visual analysis [9,10].
-For flips preceding pips: uncertainty is determined by visual domain size. AQ conditions (lower uncertainty) were the only instance where modulatory effects on tone processing by visual priming were observed in the task. This evidence suggests that anticipatory mechanisms triggered by a visual prime may reshape auditory expectations [11].

Acknowledgments

Data and a manuscript version of this work may be accesible from the Open Science Foundation and bioRxiv respectively [12].
This work was supported by the *Fondo Profesor Dr. Roberto Caldeyro Barcia* from the Agencia Nacional de Investigación e Innovación (Uruguay) under the code PD_NAC_2018_1_150365.

References

[1] Yu 2014. In Nobre & Kastner The Oxford Handbook of Attention, OUP
[2] Rohe & Noppeney 2018. ENeuro, 5(1)
[3] Dayan & Zemel 1999. ICANN '99, 1017–1022
[4] Feldman & Friston 2010. Frontiers in Human Neuroscience, 4
[5] Roseboom et al. 2009. Journal of Vision, 9(12), 4.1-8
[6] van Atteveldt et al. 2007. Cerebral Cortex, 17(4), 962–974
[7] McGurk & Donald 1976. Nature, 264(5588), 746–748
[8] O'Sullivan et al. 2015. Cerebral Cortex, 25(7), 1697–1706
[9] Parise & Ernst 2016. Nature Communications, 7, 11543
[10] Foxe & Schroeder 2005. Neuroreport, 16(5), 419–423
[11] Nobre & Rohenkohl 2014. In Nobre & Kastner The Oxford Handbook of Attention, OUP
[12] Cervantes Constantino et al. 2020. bioRxiv 2020.07.30.229948