Audiovisual integration during motion adaptation modulates brain activity in the early visual cortex

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Background

- Traditionally, modality-specific cortical areas have been considered independent in multisensory integration.
- Challenging this view, our previous psychophysical study[1,2] demonstrated the audiovisual(AV) integration in the early visual pathway using the motion aftereffect (MAE), an illusory motion caused by adaptation to physical motion[3].
  → **"Adaptation to visual motion accompanied by a congruent direction of auditory motion enhanced the intensity of the subsequent visual MAE."**

The aim of the present study

- We used functional magnetic resonance imaging (fMRI) to examine the neural mechanisms underlying such AV direction congruence effect prompting AV integration.
- Specifically, we focused on the visual cortices V1 and V2 since neural adaptation arising from direction-selective neurons in those visual areas has been considered the MAE's neural basis.

Methods

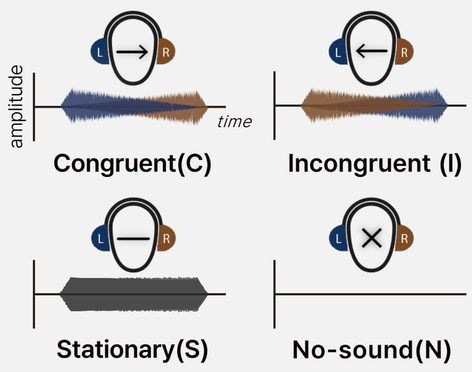
Participants

- 19 participants (14 females, ages: 20-30)

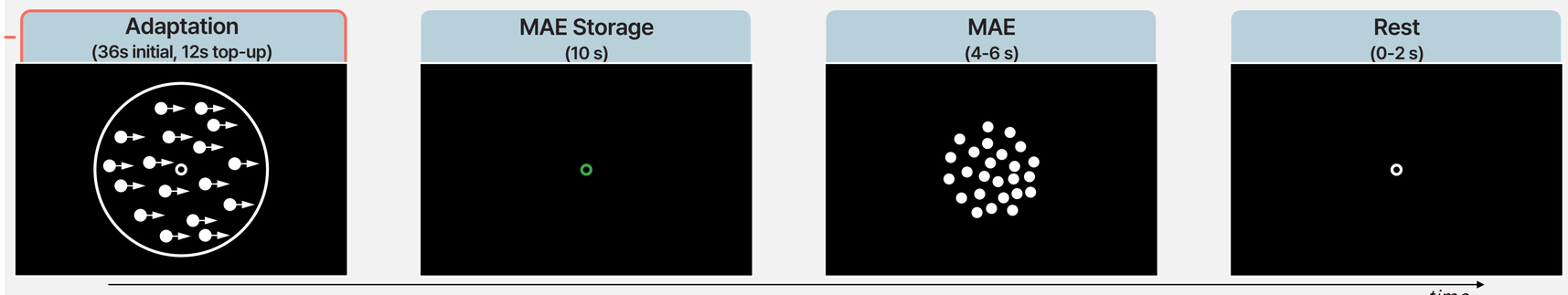
Stimuli

- Visual stimuli: Random-dot kinematogram (RDK; 4° of visual angle; 100% coherence) moving to left or right
- Auditory stimuli: 2s of moving sounds generated by simulating inter-aural intensity differences in white noise (sampling rate: 44.1kHz)

Sound Conditions



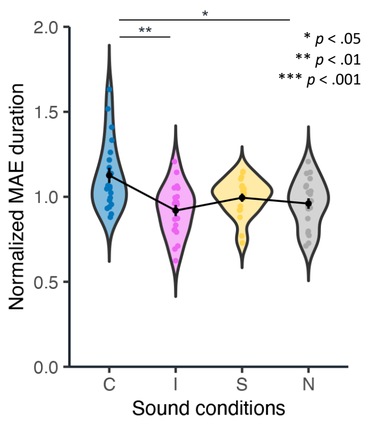
Procedures



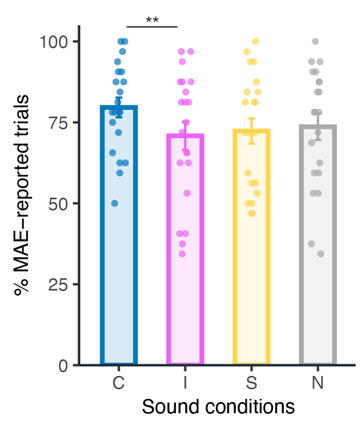
- Adaptation to visual motion direction (left, right).
- Fixation task: Count the number of fixation size changes.
- Color feedback to the fixation task.
- MAE task: Report the MAE direction (left, right, no-motion) and the duration.

Results

1) Behavior: AV direction congruence effect

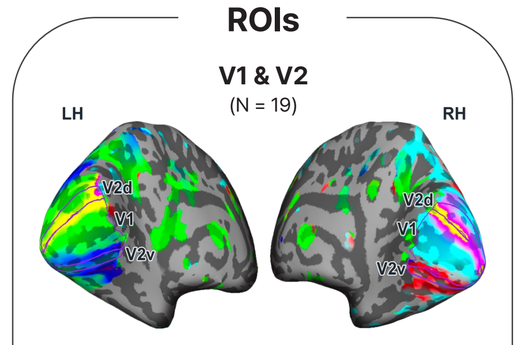


AV congruence effects on visual MAE duration (F (3, 60) = 5.229; p = .003, BF_{10} = 91.16).

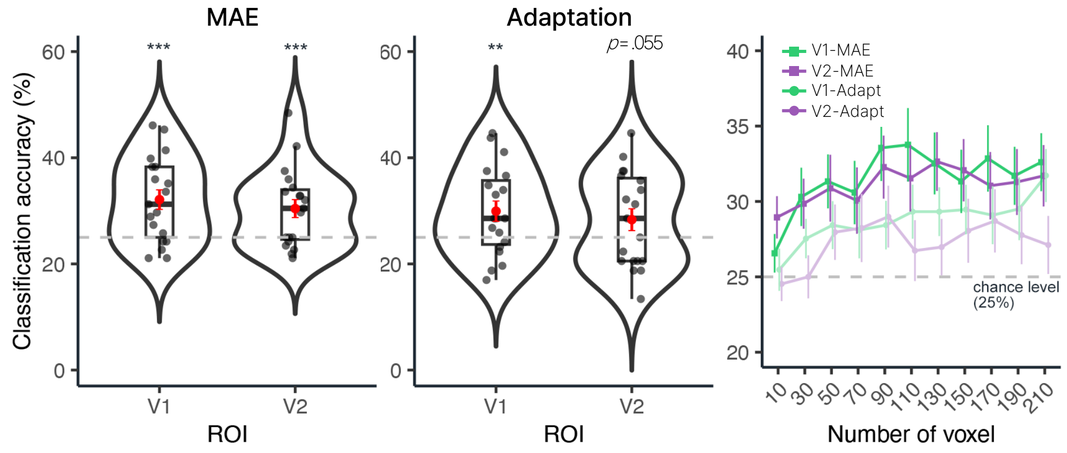


More frequent MAE experience in the congruent condition (F (3, 60) = 3.968; p < .05).

3) Pattern Classification Results

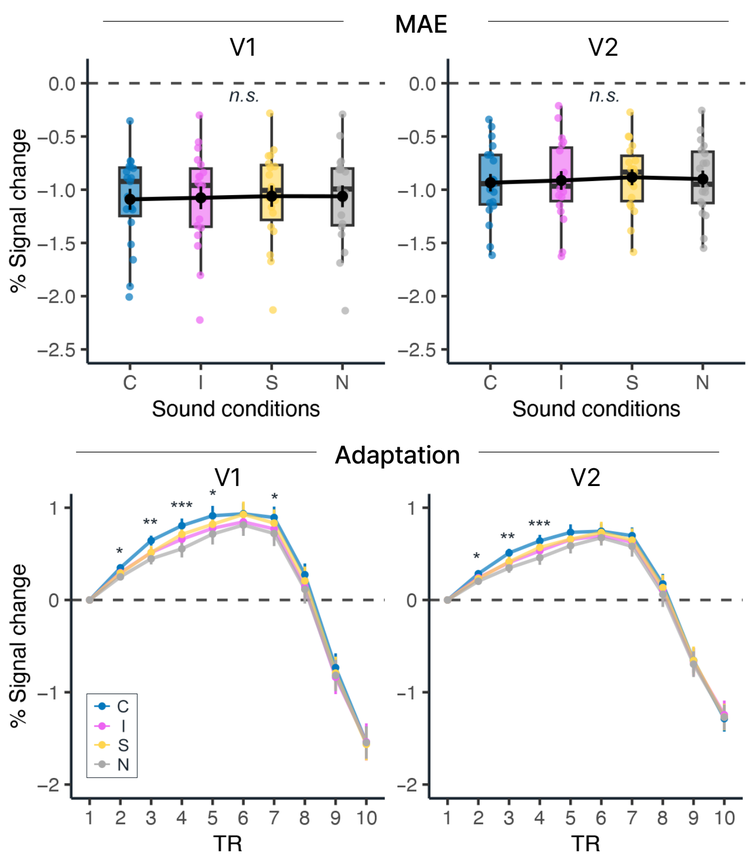


- V1 and V2, defined by retinotopy.
- Selection of the top 150 voxels responsive to visual motion (left, right) in each ROI, using a separate localizer.



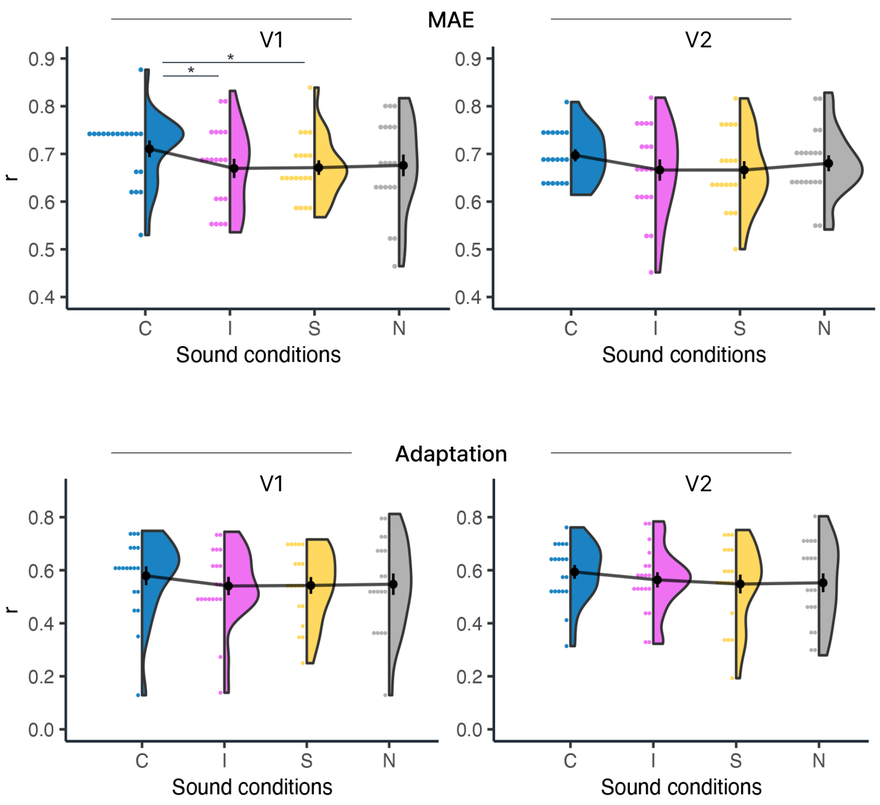
Successful pattern decoding of the four sound conditions from the voxel-wise patterns in V1 and V2 during MAE and Adaptation.

2) Univariate Results



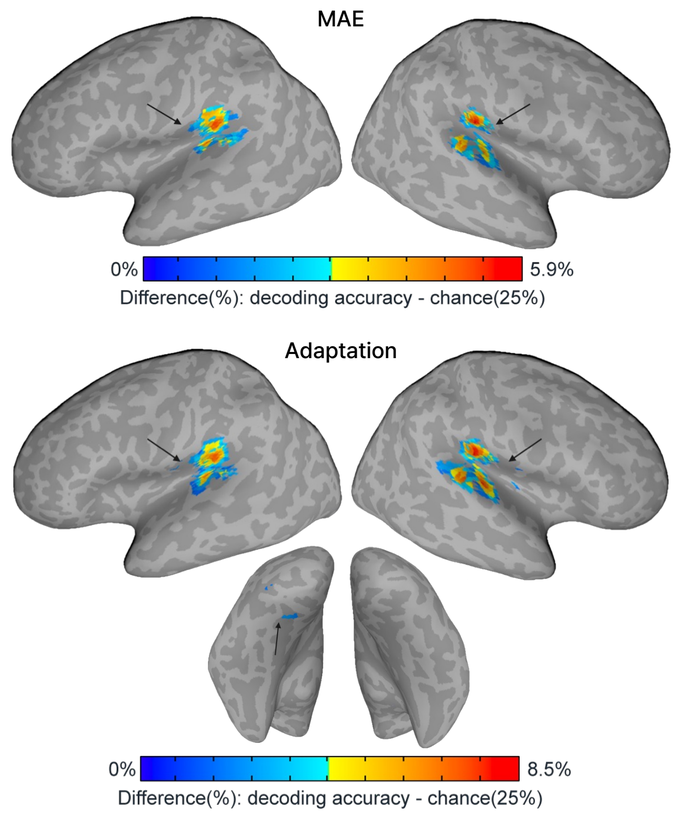
Enhanced neural responses in V1 and V2 when adapting to the congruent direction of AV motion, which in turn induced the longer MAE duration.

4) Pattern Correlation Results



More reliable voxel-wise patterns for the visual MAE in V1 and V2 when the congruent sound direction was accompanied by visual motion adaptation.

5) Searchlight Results



Observation of substantial portions of the bilateral superior temporal gyrus (STG) and transverse temporal gyrus for MAE and adaptation, and a handful of visual cortex for adaptation.

Conclusion

- Contrary to the traditional view of the early visual cortex as impenetrable to other senses, we demonstrated the influence of auditory motion information in the early visual cortex, using the MAE paradigm.
- Consistent findings across psychophysical and fMRI data suggest that the integration of AV motion information at the perceptual level is represented in the visual cortex.

References & Acknowledgement

[1] Park, M., Blake, R., Kim, Y., & Kim, C.-Y. (2019). *Sci. Rep.*
[2] Park, M., Blake, R., & Kim, C.-Y. (2024). *Neurosci. Conscious.*
[3] Mather, G. (1980). *Perception.*

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