The Dynamics of Categorical Decision-making in a Multisensory Context

Christy, Jianhua Li [1,2], Lin Hua [2,3] & Sophia, Wei Deng [1,2]

[1] Department of Psychology, University of Macau
[2] Centre for Cognitive and Brain Sciences, University of Macau
[3] Faculty of Health Sciences, University of Macau

Introduction

Background

- In the multisensory context, the task performance can be facilitated (faster response or higher accuracy) or hindered.
- Our brain accumulates the evidence for decision-making. A motor response is elicited if a criterion is reached. As a result, the decision-making process can be separated into **sensory encoding** and **decision selection** stages.

Aim

- To explore how the goal-relevant processes are affected by the inter- or intra-modality irrelevant information.

Hypothesis

- affected behavior performance
- temporally distinct neural components
- modulated by the modality of stimuli

Methods

Participants: 39 undergraduates

Data acquisition: 128-channel EGI

Task 1: visual categorical decision-making

Task 2: auditory categorical decision-making

- baseline condition
- visual-distractor condition (vd)
- auditory-distractor condition (ad)

Data analysis:

behavior data: Linear Mixed-effects Model

EEG: Linear Discrimination Analysis (LDA)

- Forward model: to identify temporal transitions between various components
- Permutation test: to quantify whether and when the discriminator performance changed

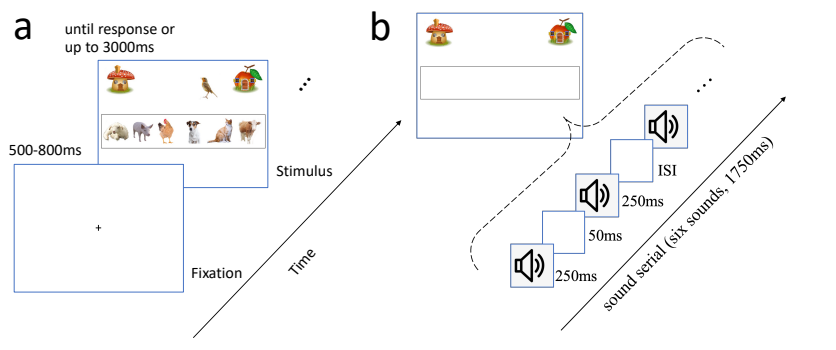

Fig.1 Participants were required to categorize, whether there is a bird or a dog inside the black frame (visual task, **a**) or their sounds (auditory task, **b**). In vd, a bird or a dog is presented outside the black frame. In ad, the outside animals is replaced by the sound of bird or dog in one ear. In the baseline condition, no visual or auditory distractors.

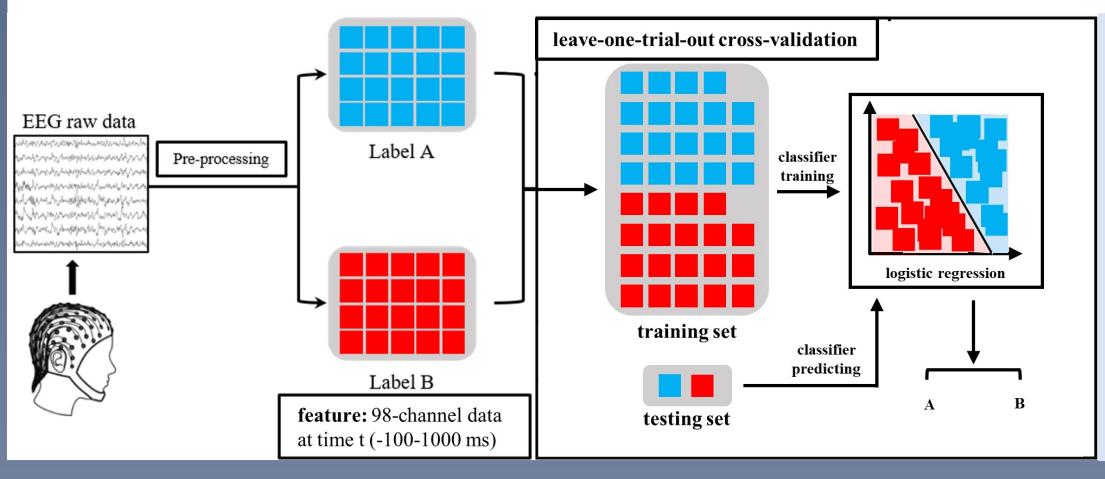

Fig. 2: After pre-processing, linear multivariate single-trial discrimination analysis was conducted. To optimize the number of distinct spatiotemporal components and compare the discriminator performance between ad- and vd-baseline comparisons, forward model and the percentile bootstrap permutation test were used.

Results

$$ACC_{Distractor\ Effect\ Value} = ACC_{ad/vd} - ACC_{baseline}$$

$$RT_{Distractor\ Effect\ Value} = RT_{baseline} - RT_{ad/vd}$$

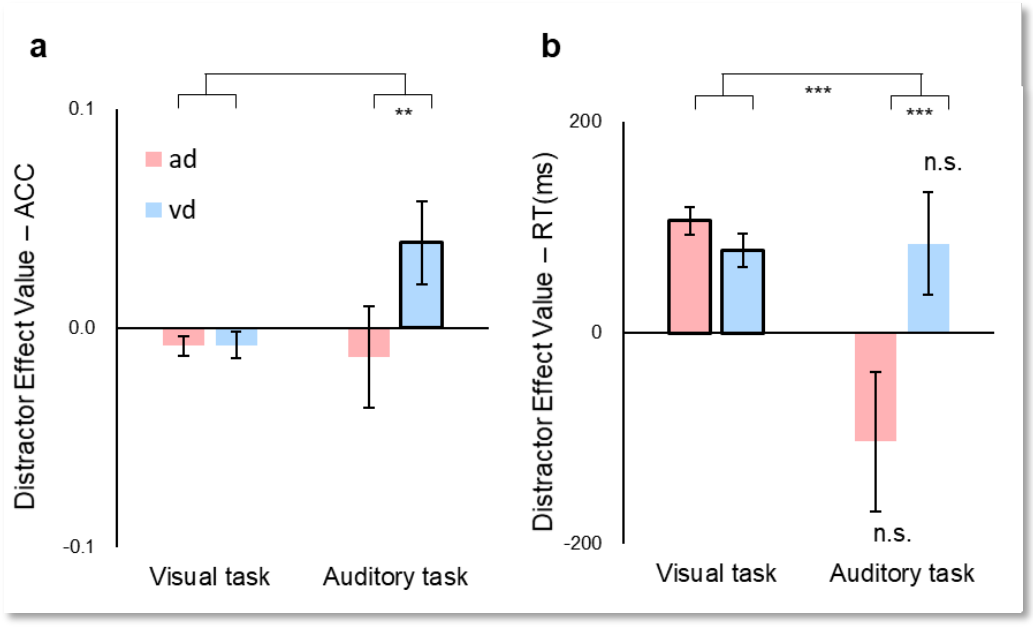

Fig. 3: The effects of visual and auditory distractors were **identical on the visual task but different on the auditory task**. They can speed up visual categorical decision-making. In contrast, for the auditory task, visual distractors had a facilitation effect, while auditory distractors were likely to slow down categorical decision-making. Error bars denote Standard Error. Significantly different from 0 is indicated by its bold black frame for each bar. $^{**}p < 0.01$, $^{***}p < 0.001$, n.s.: $p < 0.1$; ad = auditory distractor; vd = visual distractor.

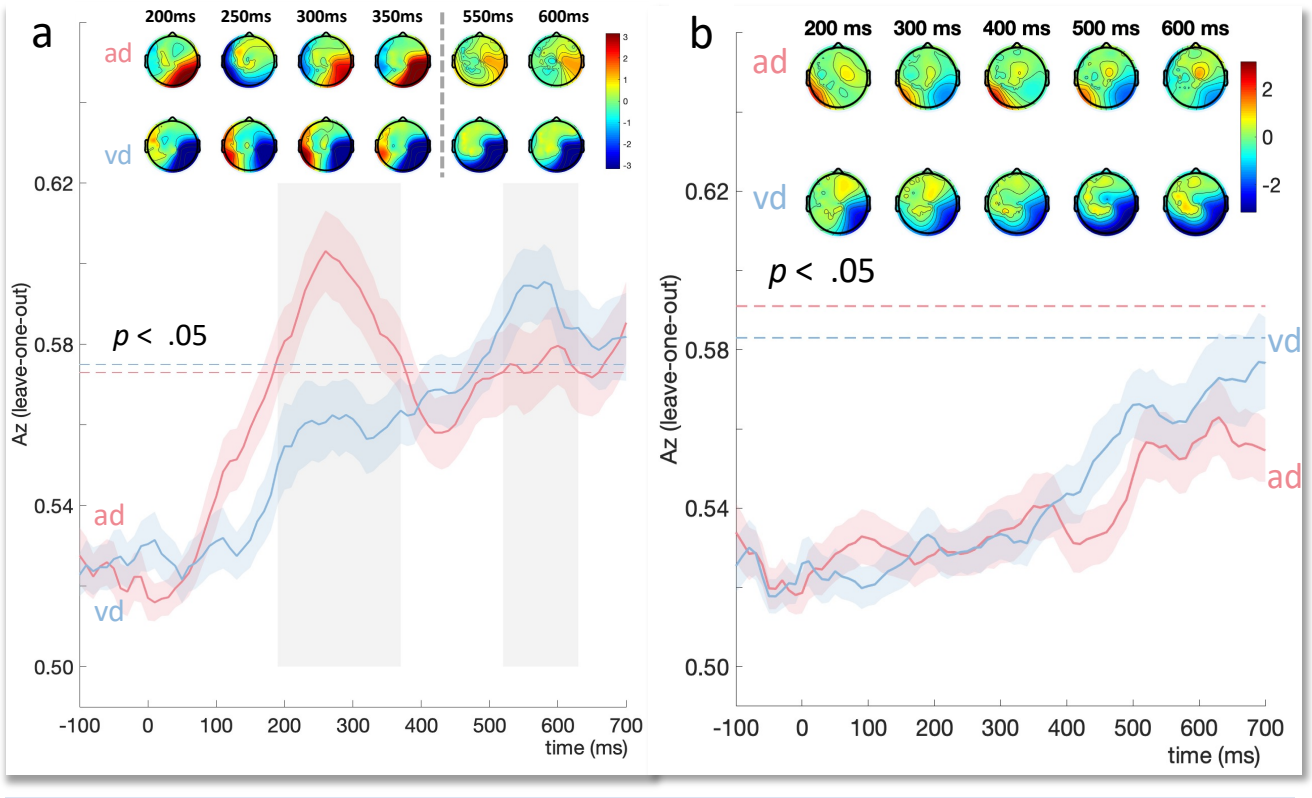

Fig. 4: The effects of visual and auditory distractors on neural representations **were different on the visual task (a) but identical on the auditory task (b)**. Mean discriminator performance (A_z) after a leave-one-trial-out cross-validation procedure for the ad-baseline (red) and vd-baseline comparison (blue). Horizontal dotted lines represent the group average permutation threshold for statistical significance at $p < 0.05$. Shaded error bars are bootstrapped standard errors. **a.** Early (190 – 370ms) and Late (520 – 630ms) EEG component windows of auditory and visual distractors on visual decision-making are indicated by shaded gray bars. **b**. no significant difference was found between baseline and distractor condition.

Discussion

How is the categorical decision-making influenced by the inter- or intra- additional information?

evidence accumulation | modality properties

a) different behavior performance √
b) temporally distinct neural components √
c) modulated by the modality of stimuli √

- Mixed effect model
- LDA discrimination analysis

Conclusion

- ✓ Visual and auditory distractors have distinct effects on both Visual and Auditory categorical decision-making, evident on the neural and behavioral levels, respectively.
- ✓ Distractors are processed both during sensory encoding and decision formulation.

Contribution

a) an exploration for the the natural categorization as a real-life context
b) an exploration of the information encoding in high-order cognition
c) both the inter- and intra-modality information on visual and auditory processing are considered
d) the first attempt to inspect the neural dynamic processes and mechanism of the irrelevant information effect on auditory categorization

Main References & Acknowledgements

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ID: 626 0261 8815

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