



Effects of cardiac cycle and respiration phase on trace eyeblink conditioning in elderly adults

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INTRODUCTION

Associative learning allows organisms to make predictions about their environment and adapt their behavior accordingly. Our recent research suggests that a certain phase of the cardiorespiratory rhythm (expiration-diastole) may be beneficial for learning trace eyeblink conditioning (TEBC) in healthy young adults. In this study, we investigate how the phases of breathing and heartbeat (i.e., expiration and diastole vs. inspiration and systole) impact associative learning in healthy elderly adults.

METHODS

PARTICIPANTS: Recruited 50 and final sample consisted of 41 participants (9 males and 32 females), aged 70–83 years, with no diagnosed memory impairment.

PHYSIOLOGICAL MEASURES: EEG, ECG, EMG, and respiration.

STIMULI AND PRESENTATION

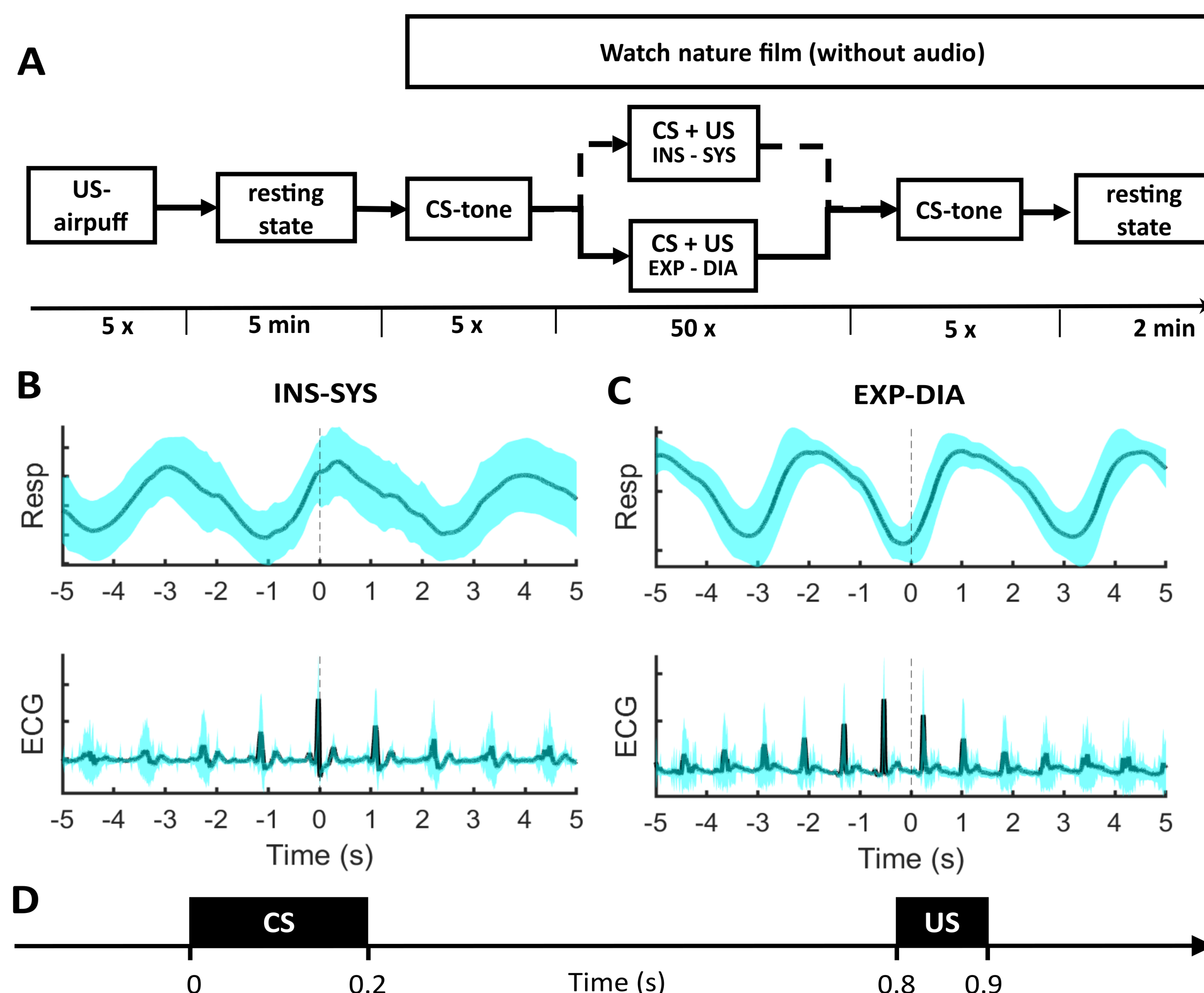


Figure 1. Schematic illustration of the experiment. A) Participants were trained in classical trace eyeblink conditioning (TEBC), while watching a silent nature film. Abbreviations: US = unconditioned stimulus, CS = conditioned stimulus. Paired trials were presented either at B) systole during inspiration (INS-SYS) or at C) diastole during expiration (EXP-DIA). Cyan area in B and C represents standard deviation of 50 trials and the average is shown on top in black. Respiration (Resp) phase was measured using a stretch belt: lungs are full when the signal is at peak. Cardiac cycle phases were determined from the electroencephalogram (ECG). D) The 200-ms CS and the 100-ms US during a paired TEBC trial were separated by a 600-ms silent interval.

QUESTIONNAIRE

Participants answered a short questionnaire regarding the content of the film and the TEBC task (Waselius et al., 2022) to assess their concentration on the film and awareness about CS and US.

COGNITIVE TEST: CERAD

- Cognitive status of each participant was assessed to determine the memory impairment in the elderly individuals (Alenius et al., 2022).
- Group differences were assessed using independent samples t-test.

REFERENCES

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- Alenius, M., Ngandu, T., Koskinen, S., Hallikainen, I., Hänninen, T., Karrasch, M., Kivipelto, M., Raivio, M. M., Laakkonen, M.-L., Krüger, J., Suhonen, N.-M., & Hokkanen, L. (2022). Education-Based Cutoffs for Cognitive Screening of Alzheimer's Disease. *Dementia and Geriatric Cognitive Disorders*, 51(1), 42–55.

RESULTS

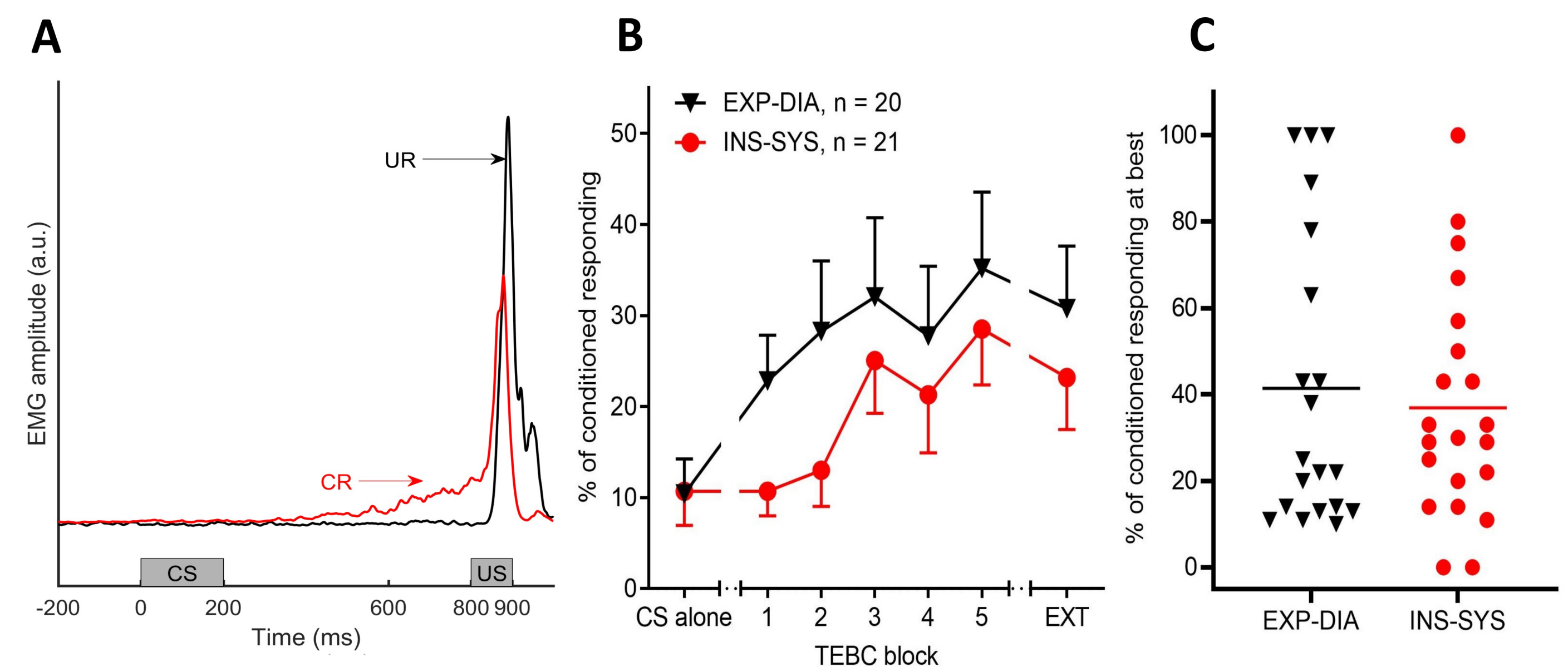


Figure 2. Learned responding (%) during TEBC did not differ in participants to whom the stimuli were presented at diastole during expiration (EXP-DIA) compared to participants to whom the stimuli were presented at systole during inspiration (INS-SYS). A) Eye blinks were determined from EMG activity. A blink was considered an adaptive conditioned response (CR) if it started after the conditioned stimulus (CS) and shielded the eye from the airpuff-unconditioned stimulus (US). UR = unconditioned response. B) Both groups learned equally well. C) To evaluate optimal performance, we determined the highest percentage of CRs for each participant during a given 10-trial block towards the end of TEBC (blocks 3 to 5). There was no difference between groups in the final outcome of TEBC.

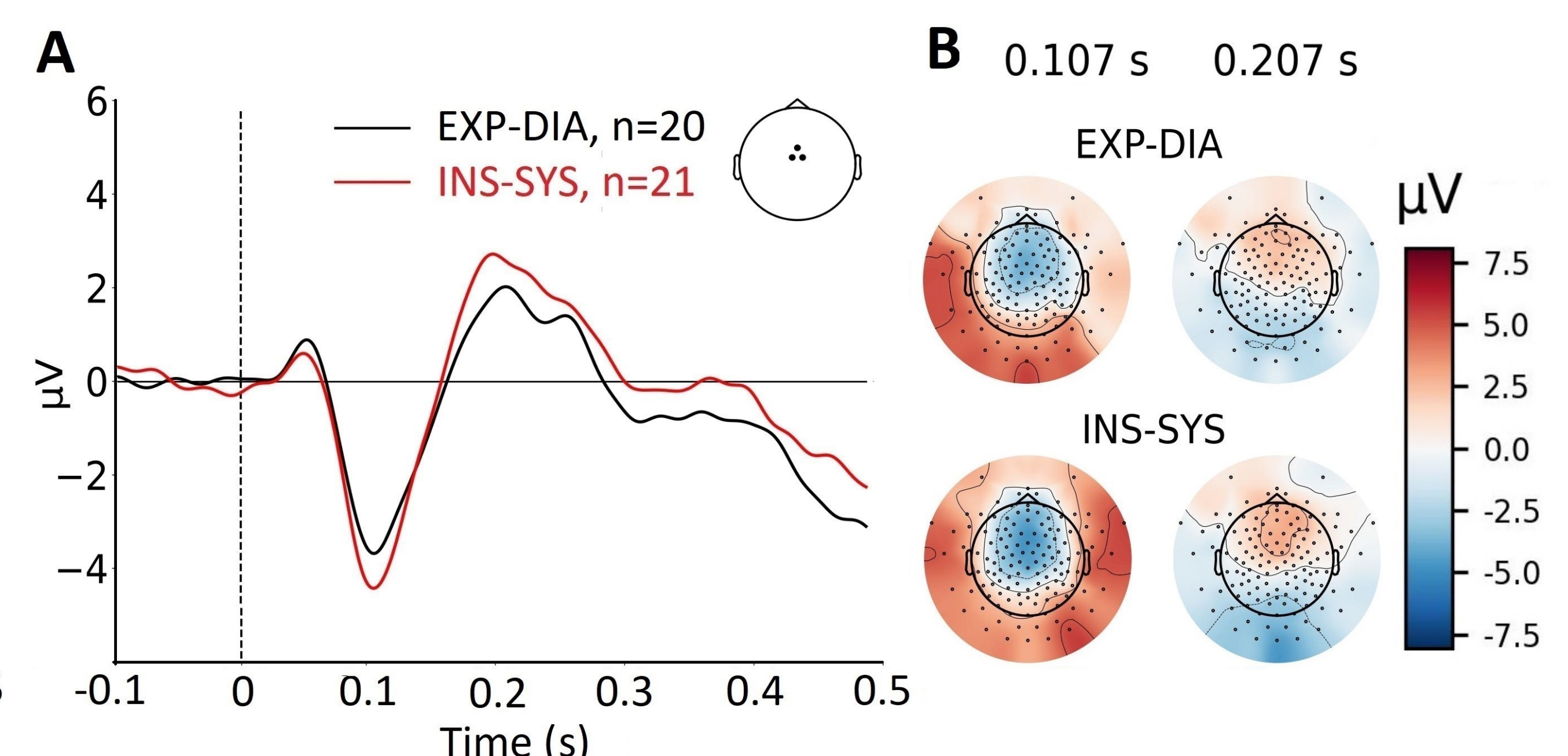


Figure 3. The tone-conditioned stimulus evoked a similar response in the brain of elderly participants regardless of whether it was presented starting at diastole during expiration (EXP-DIA) or starting at systole during inspiration (INS-SYS). A) The grand averaged ERP waveform in the frontocentral region (channels 6, 7, and 106) plotted separately for EXP-DIA and INS-SYS groups. B) Topographic maps illustrate the auditory N1 peak, occurring at 107 ms, and the auditory P2 peak, occurring at 207 ms, separately for both groups.

CONCLUSION

- Elderly adults can become aware of the CS-US association during classical conditioning, similar to younger participants (Waselius et al., 2022).
- However, they exhibit reduced brain responses to the CS and an impairment in acquiring the motor conditioned response.
- Interestingly, the timing of the CS in relation to the cardiorespiratory rhythm phase did not affect CS-evoked brain responses or acquisition of the conditioned eye blink.
- Participants trained at inspiration-systole reported better awareness of the CS-US contingency compared to those trained during expiration-diastole.
- These findings highlight the challenges faced by elderly adults in adapting their behaviour to environmental changes.