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# Rhythmic encoding improves recognition memory

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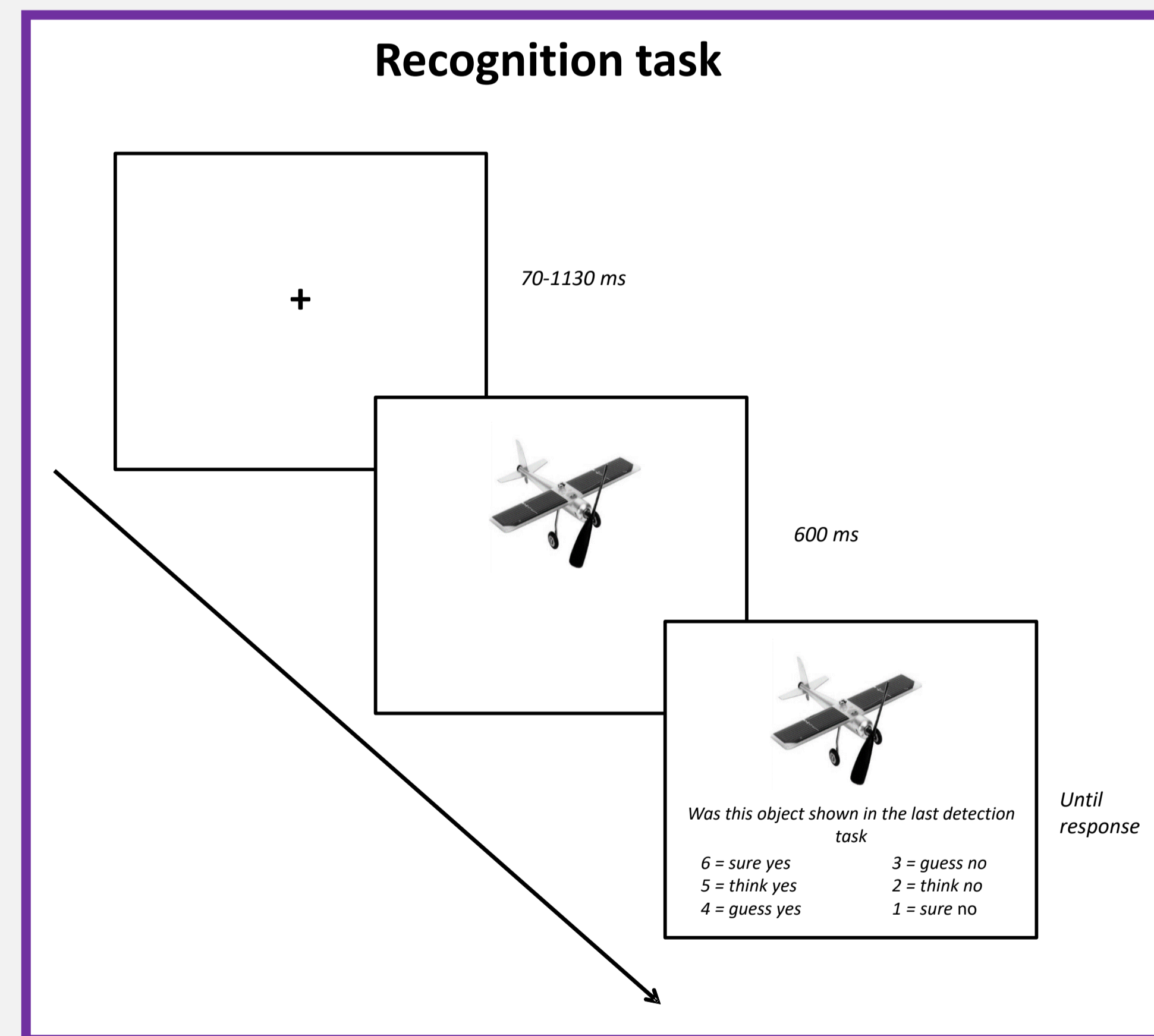
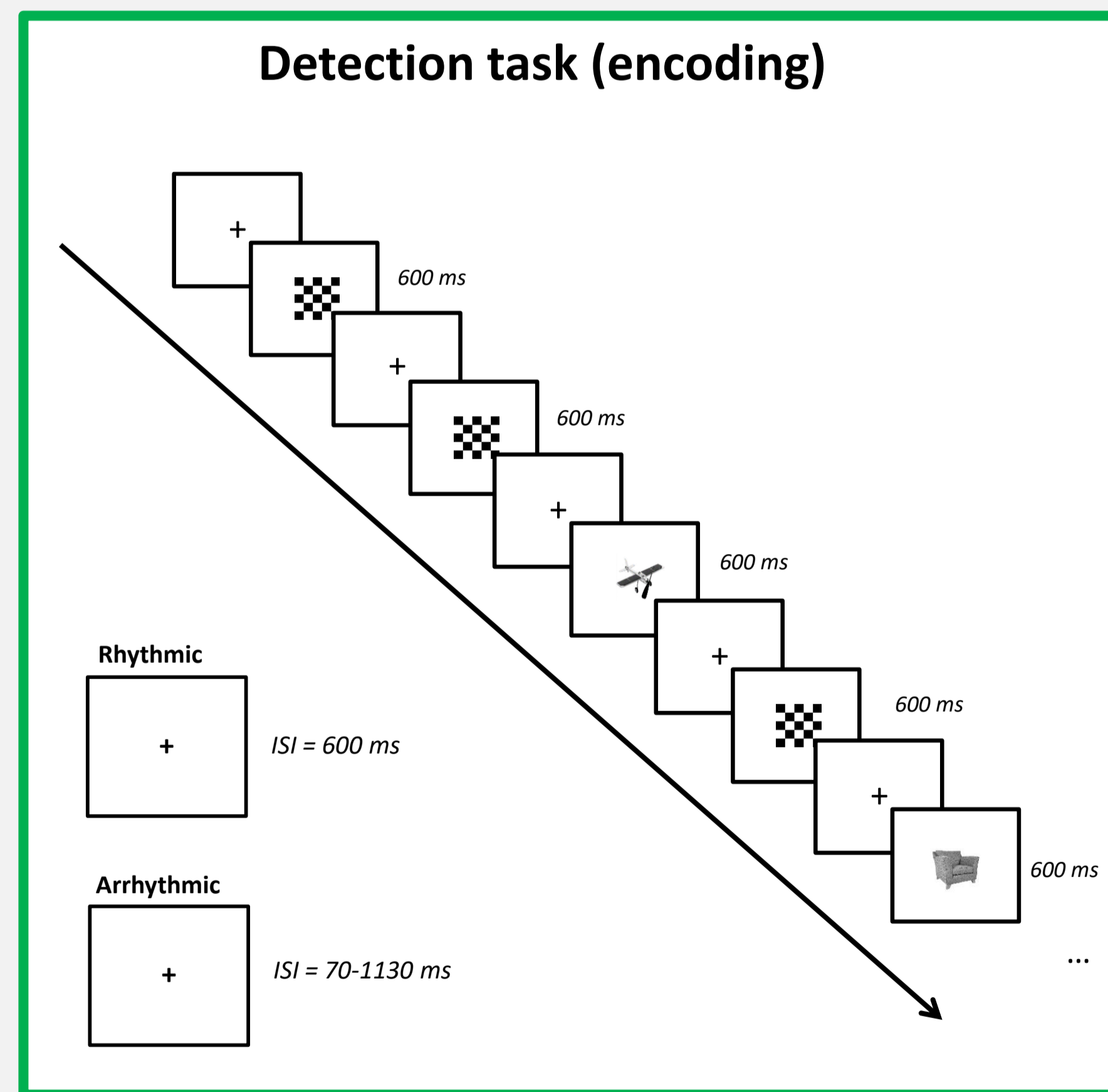
## Highlights

- Rhythmic temporal structure at encoding enhances later recognition performance
- Enhanced PLF for rhythmic over arrhythmic conditions
- ERP effects of temporal structure at encoding correlated with behaviour at recognition
- Memory specific ERP effects at retrieval influenced by temporal structure at encoding
- FN400 not affected by temporal structure whilst LPC old/new effect only present for rhythmic items

## Background

Presenting events in a rhythm has shown to enhance perception and facilitate behaviour for in compared to out-of-synchrony stimuli (Nobre & van Ede, 2017; Haegens & Golombic, 2017). It is well established that the way in which information is processed during encoding determines how efficiently memories are formed and later retrieved (Davichi & Dobbins, 2008). Recently, Clouter et al. (2017) showed that associative memory depends upon the timing synchrony between different sensory cortices at the theta frequency, and Thavabalasingam et al. (2016) reported on the effect of temporal structure on recognition memory. However, little is known how rhythm affects recognition memory and the underlying neural processes involved. The current research addresses this.

## Methods and Procedure



**Detection task**  
Participants (N=24) viewed a continuous stream of checkerboards and objects. Task was to press space as quickly as possible if the object was an animal (10% of trials)

**Recognition task**  
Participants were presented with an object and asked whether or not it has appeared in the prior detection task.

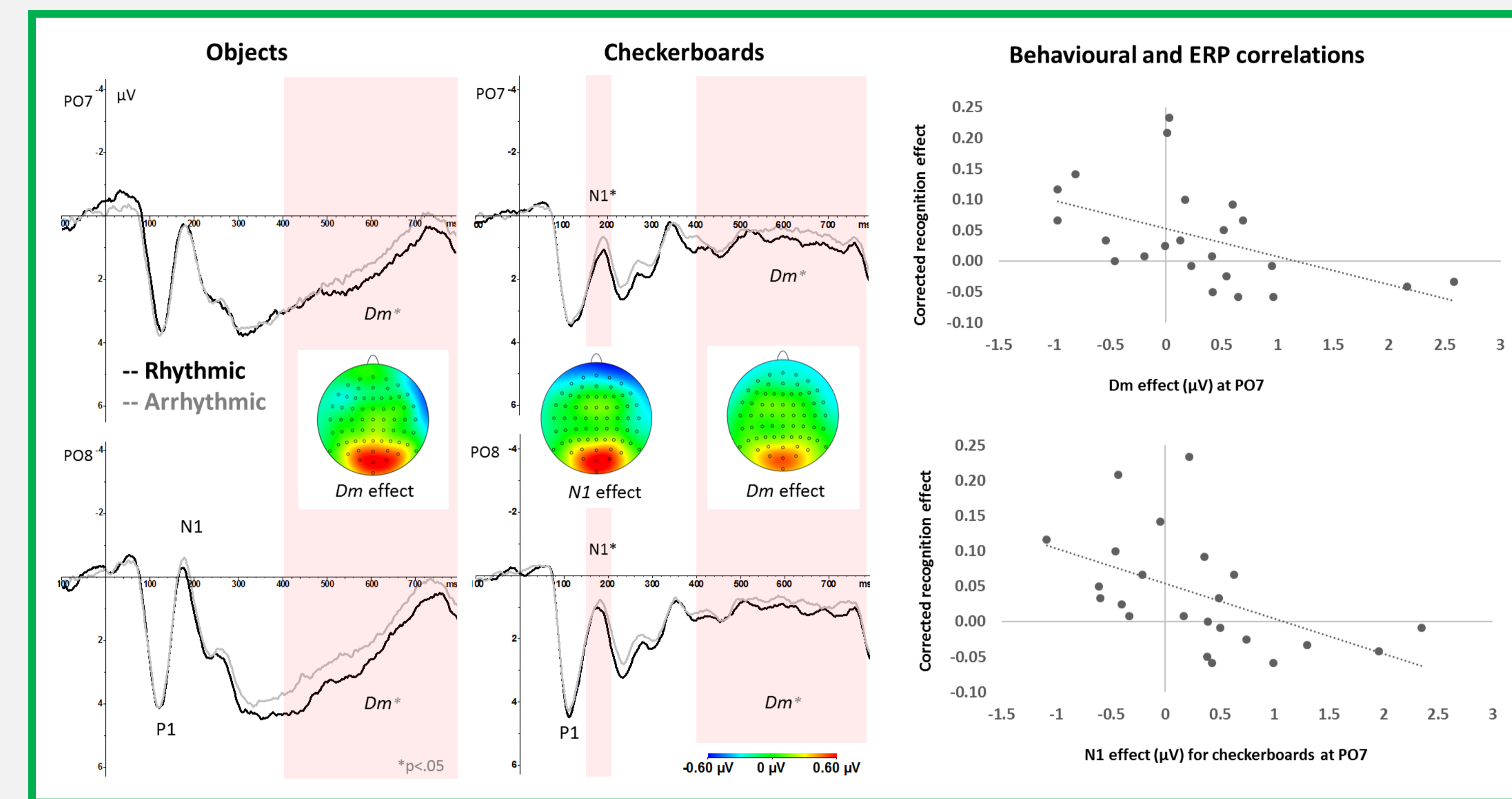
**Design**  
Encoding - 3 rhythmic and 3 arrhythmic encoding blocks, each with 40 objects and 120 checkerboards. (ratio 3:1)

Recognition test - 40 old and 40 new objects per block

**References:**  
Nobre, A. C., & van Ede, F. (2018). *Nature Reviews Neuroscience*, 19(1), 34.  
Haegens, S., & Golombic, E. Z. (2017). *Neuroscience & Biobehavioral Reviews*.  
Davachi, L., & Dobbins, I. G. (2008). *Current directions in psychological science*, 17(2), 112-118.  
Clouter, A., Shapiro, K. L., & Hanslmayr, S. (2017). *Current Biology*, 27(20), 3143-3148.  
Thavabalasingam, S., O'Neil, E. B., Zeng, Z., & Lee, A. C. (2016). *Frontiers in psychology*, 6, 2062.



## Results



**Behaviour:** Recognition was significantly greater in the rhythmic condition than the arrhythmic condition ( $p = .032$ ,  $d = 0.30$ ) but there was no difference in recognition RTs.

**ERP:** A FN400 old/new effect was present in both conditions with the LPC old/new effect only for rhythmically encoded objects. Bayes Factor analysis (0.24, 0.034% error) confirmed no difference of the LPC in the arrhythmic conditions.

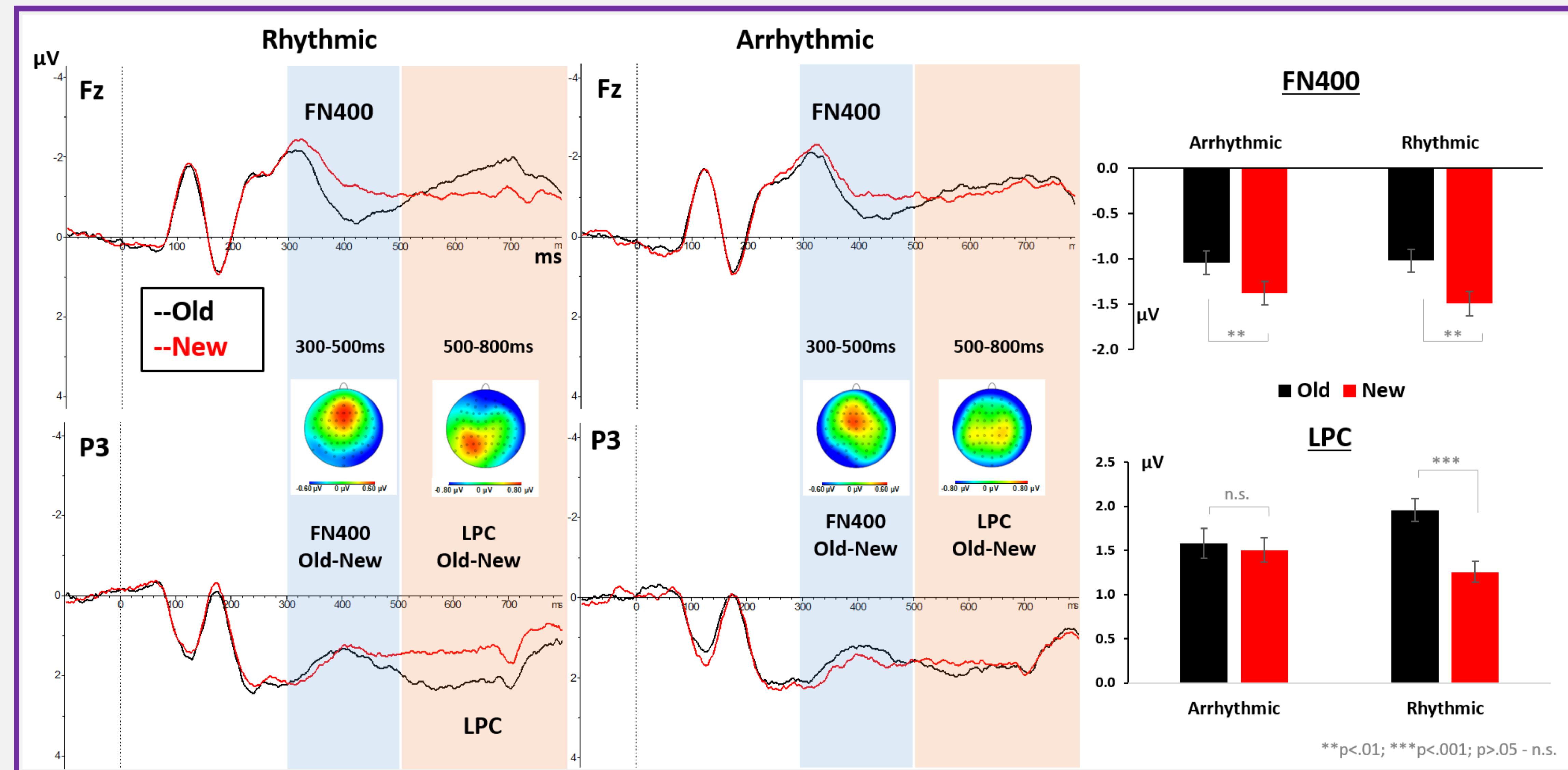
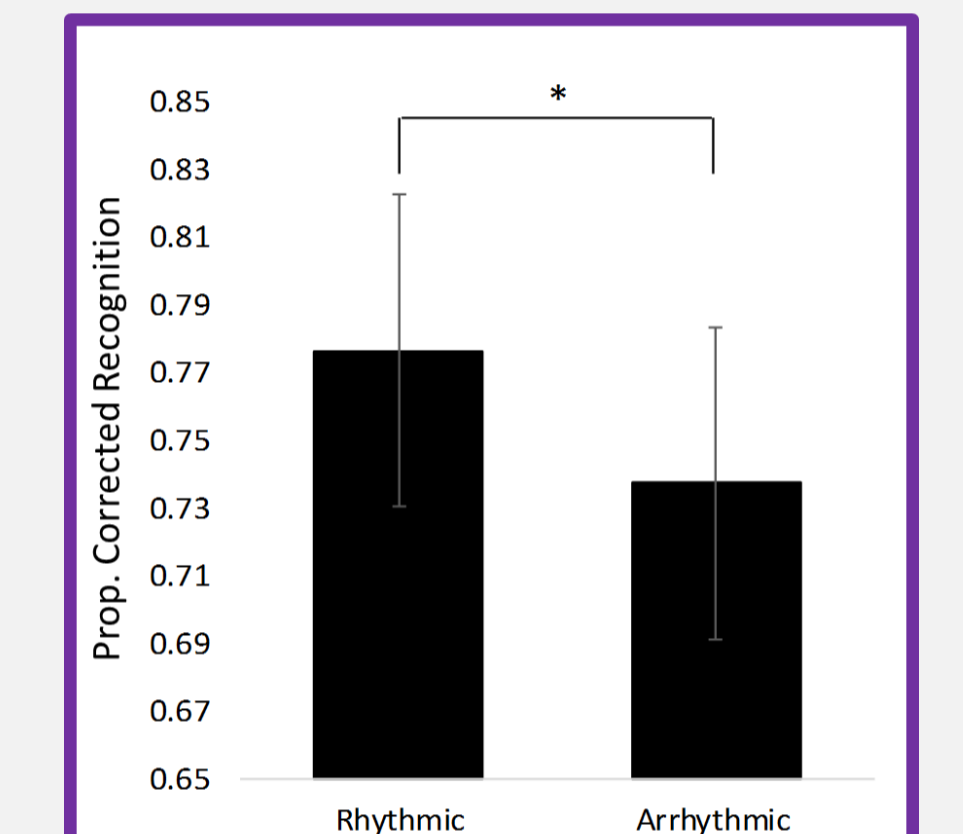
## Detection task (encoding)

Only 3/23 reported awareness that presentation timings in the detection task varied across blocks.

**EEG:** Higher Phase locking factor (PLF) in rhythmic over arrhythmic encoding condition ( $p = .001$ ,  $\eta_p^2 = .39$ ).

**ERP:** Dm effect of temporal structure for both Items and N1 effect for checkerboards only. Both effects correlate with later recognition effects.

## Recognition task (retrieval)



## Conclusion

The study provides new evidence through EEG and behavioural measures that presenting stimuli in a rhythmic manner provides a benefit to recognition memory. Memory specific components during both encoding and retrieval are affected by temporal structure, even though participants were largely unaware of timing manipulation during encoding.