

Sex differences in mental transformation of visuospatial information: study on event-related brain potential mapping

1. INTRODUCTION

Although the advantage of men's performance over women's in mental rotation tasks appears to be robust, the neural correlates underlying this difference are still unclear. In addition, the relation of specific cognitive strategies and gender is still unclear. Among them, mental rotation (object-based strategy) and a perspective-taking (observer-based strategy) could be equally effective. Electroencephalographic investigations of gender differences have been mainly assessed through event-related potentials (ERP) recorded at the late stage of information processing and mostly during mental rotation tasks. Based on the time-resolved analysis of network activations (microstates analysis), the objective of this study is twofold: (a) to describe and compare components of the ERP evoked by mental rotation and perspective taking tasks and (b) to bring novel insights into the neural underpinnings of gender differences within these two types of visuospatial manipulation of mental images especially at the attentional level.

2. METHOD

Participants & Procedure

- 26 women and 29 men were subjected to 160 trials divided in 2 blocks of 40 trials in a classical mental rotation task and 2 blocks of 40 trials in a perspective taking task presented randomly.

EEG recordings

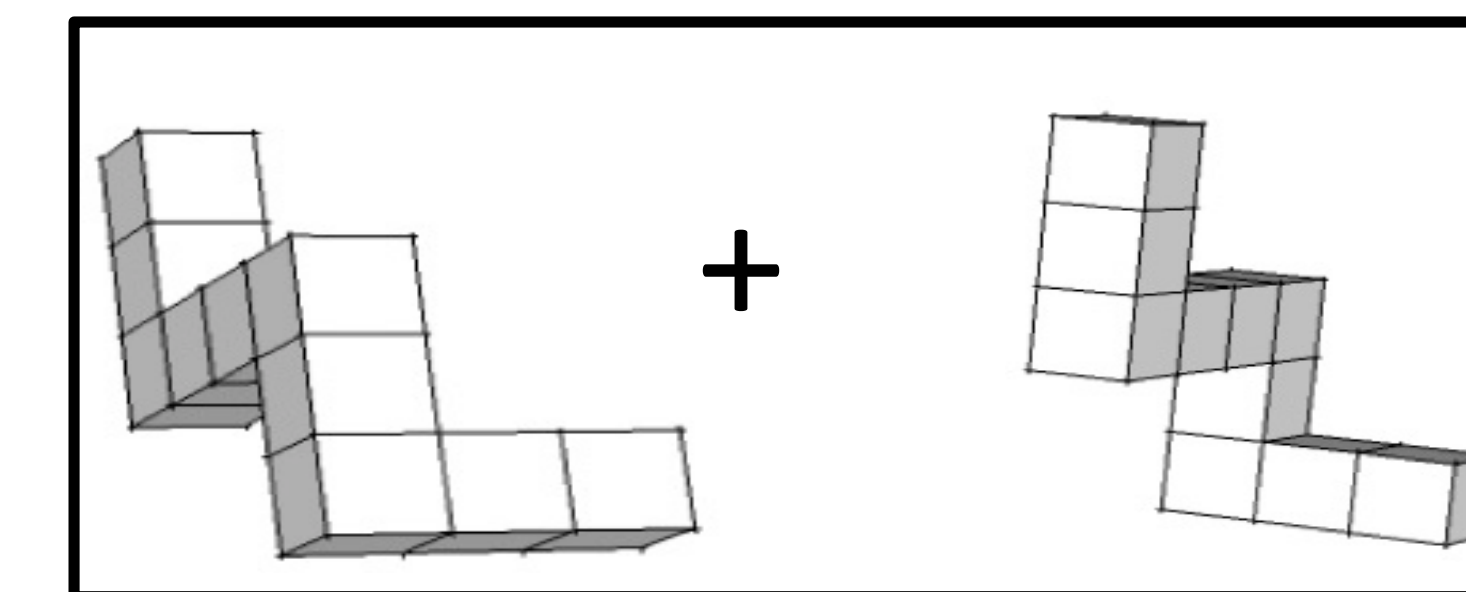
- Continuous EEG was acquired from 64-channel ActiveTwo system (Biosemi)
- EEG data were segmented into epochs time-locked to stimulus onset.

EEG processing

- EEG signals were band-pass filtered between 1 Hz and 30 Hz.
- Independent component analysis (ICA) was used to identify and remove vertical and horizontal ocular artifacts.
- EEG data were sampled at 1024 Hz, segmented into epochs of 1100 ms, starting from -100 ms before to 1000 ms after target-stimulus-onset.
- After a semiautomatic artifact rejection, the data were recalculated against the average reference.

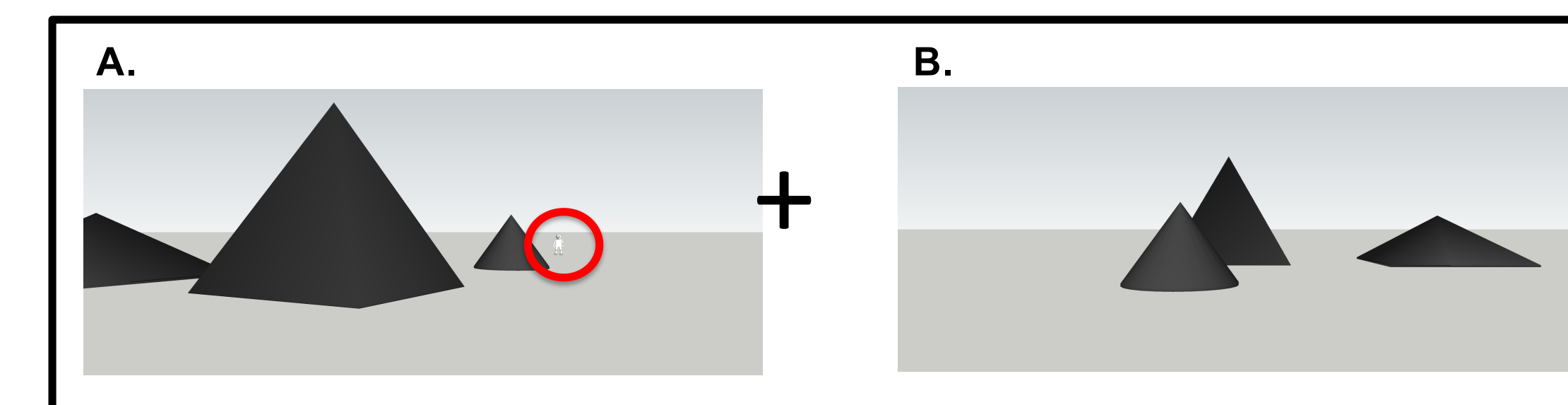
Experimental tasks

Mental rotation



"Same or not" response according to different orientations of the target stimuli

Perspective taking



A. Imagine what an avatar sees from this location. Then B. respond whether the view correspond to what the avatar sees

3.1. EEG RESULTS

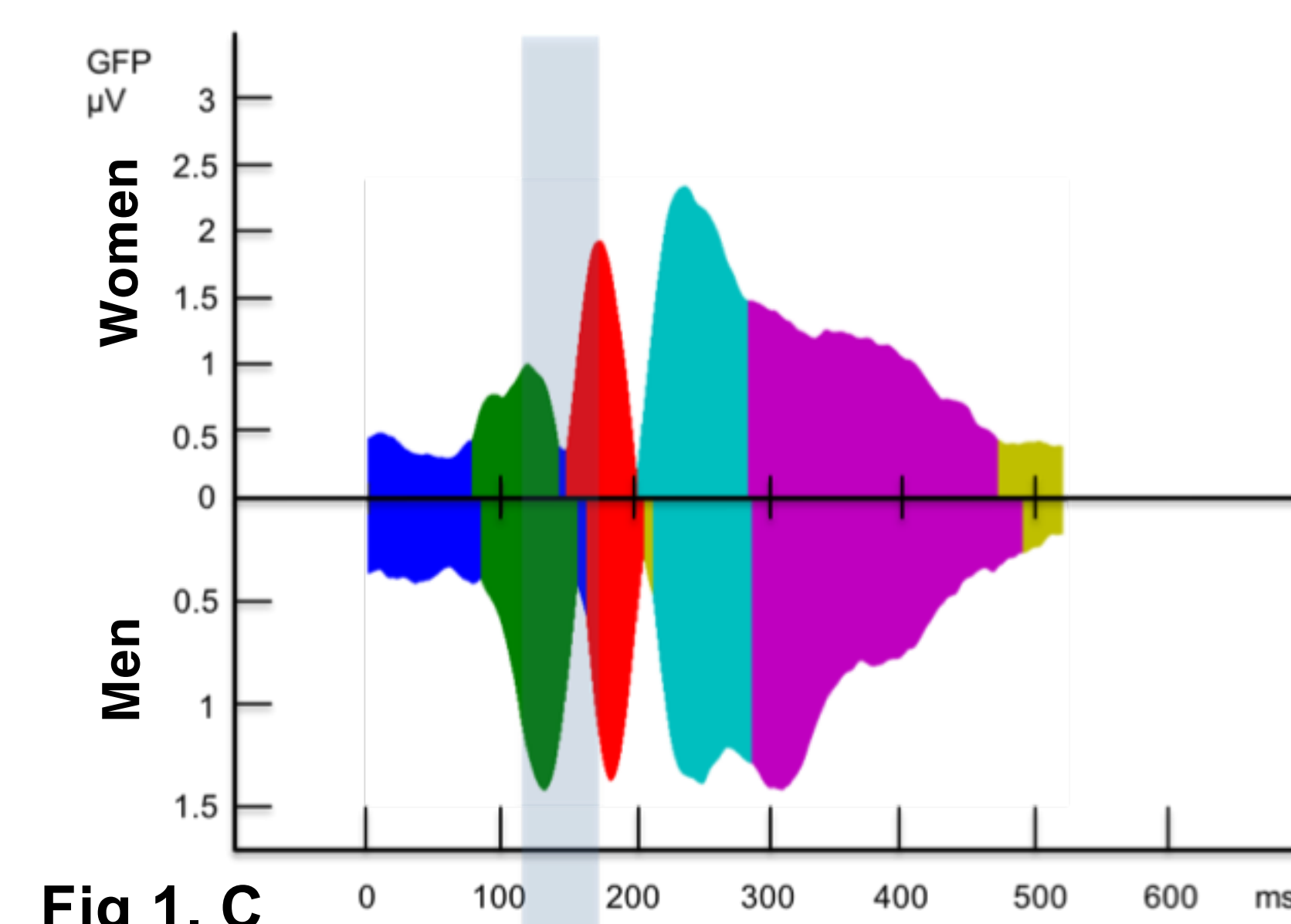
Scalp topographies and microstates analysis results for mental rotation and perspective taking conditions and for each gender

Mental Rotation

Fig 1. A

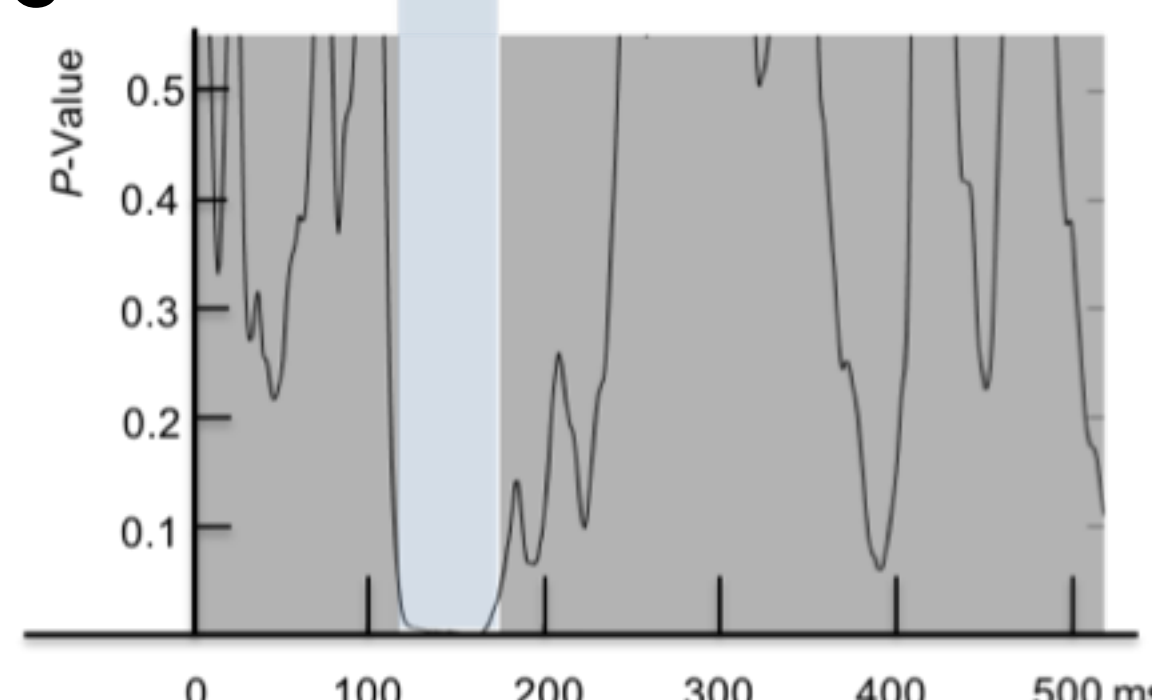


Fig 1. B



- A main effect of Gender was observed in the offset of microstate 2 (Women = 143.2 ms; Men = 156.8 ms ; $p=0.009$)
- A main effect of Gender was observed in the onset of microstate 3 (Women = 149 ms; Men = 164.7 ms ; $p=0.0492$)

Fig 1. C



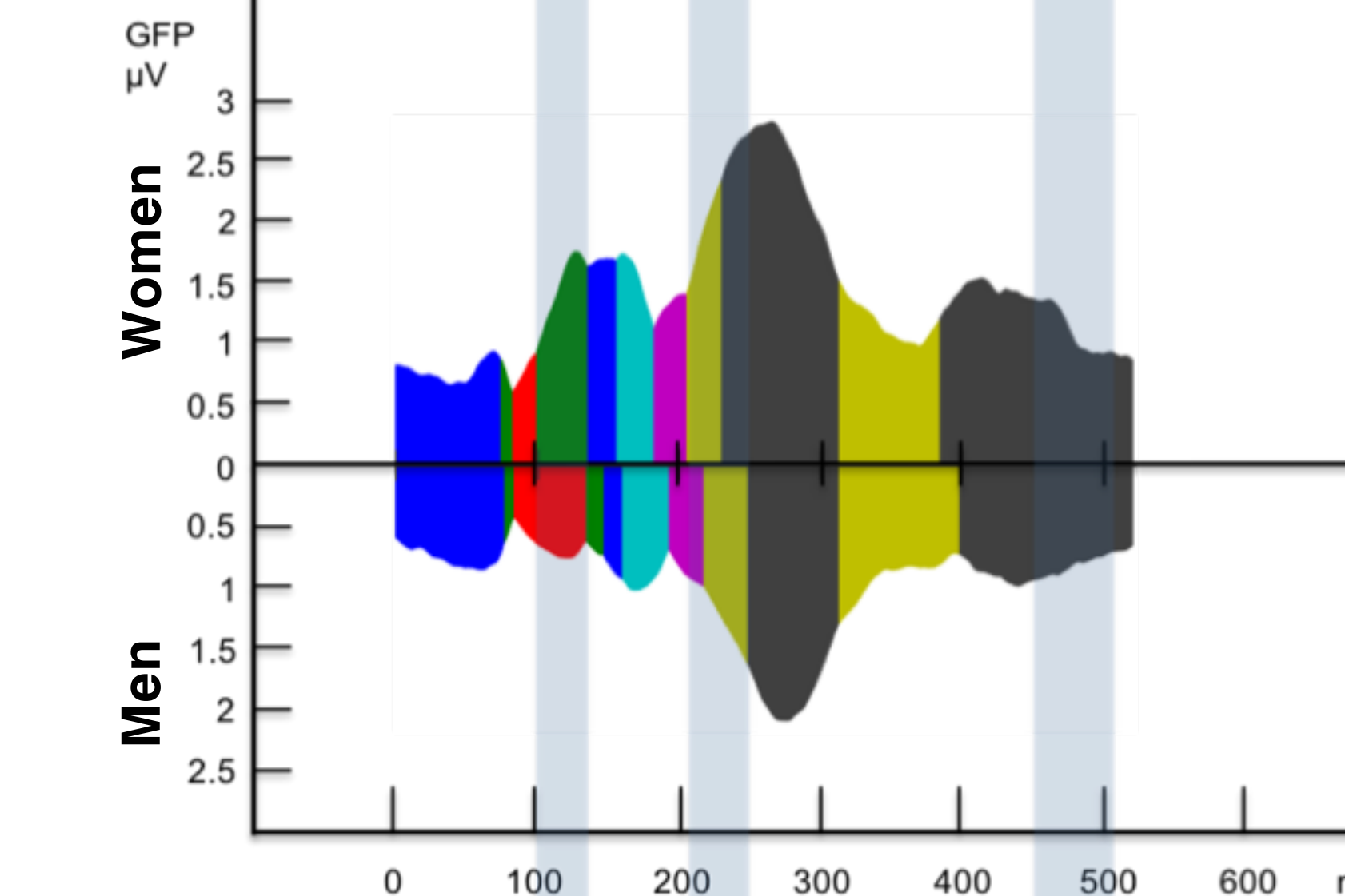
- The TANOVA revealed a main effect of Gender between 113 and 178.3 ms after stimulus onset.

Perspective taking

Fig 2. A

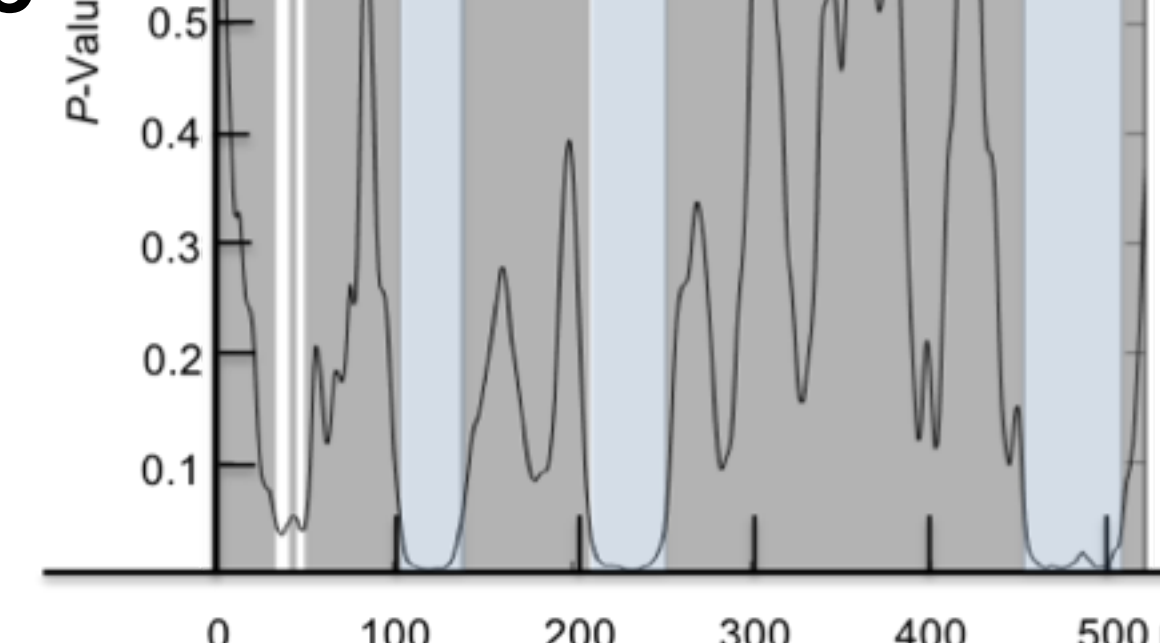


Fig 2. B



- A main effect of Gender was observed in the offset of microstate 2 (Women = 99.2 ms; Men = 134.4 ms ; $p=0.006$)
- A main effect of Gender was observed in the offset of microstate 3 (Women = 135.4 ms; Men = 147.1 ms ; $p=0.005$)

Fig 2. C



- The TANOVA revealed a main effect of Gender in 3 time windows:
 - 102-136.3 ms
 - 206.7- 252.6 ms
 - 452.8-509.4 ms

Fig 2. The template maps of seven different microstates during the perspective taking task (A), their sequence and GFP for women and men (B). TANOVA result: P-values for the comparison between the mean ERP maps of each group (women and men) for each time point in ms (C)

4. Comments

The description of the time course involved in two types of mental transformation of visuospatial images were assessed through time-resolved analysis of network activations (microstates analysis). We found:

- In both tasks, microstate 2, that corresponds by latency and topography to the P1 component, with typical positivity on occipital regions of the scalp, showed an offset latency that was earlier in women than in men.
- In the mental rotation task, microstate 3, that corresponds by latency and topography to the N1 component, with typical negativity on the parietal-central regions of the scalp, showed an onset time that was earlier in women than in men.
- In the perspective taking task, microstate 3, that corresponds by latency and topography to the N1 component showed an offset time that was earlier in women than in men.

N1 and P1 components are early visual-evoked potentials, and according to the literature, are thought to be modulated by the visual features of the stimuli as well as by selective attention. However, effects were observed on these components (later offsets in men compared to women, with no effect on the later P3 component, which is thought to be modulated by the rotational process), suggesting the presence of possible gender differences already during the visual information encoding stages. Our results thus highlight neural differences across gender during perceptive and attentional processes.

Bibliography

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Fig 1. The template maps of six different microstates during the mental rotation task (A), their sequence and GFP for women and men (B). TANOVA result: P-values for the comparison between the mean ERP maps of each group (women and men) for each time point in ms (C)