Attention facilitates three-dimensional shape from shading

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Introduction

Shape from shading refers to the ability to extract three-dimensional (3D) shape from shading patterns across an object[1].

Shape from shading has previously been described as a pre-attentive process that occurs in parallel across the visual field[1,2].

Recent evidence has challenged this notion, instead suggesting that top-down attention is necessary for late-stage processing related to shape from shading[3].

Here, we measure event-related potentials (ERPs) whilst participants passively view or attend to two-dimensional (2D) and 3D shapes.

Hypotheses

H1: There is an early stage of processing for shape from shading that occurs without the need of top-down attention.

Predicted Result: There will be a larger N1 component for 3D compared to 2D shapes during passive viewing of the stimuli.

H2: There is a relatively later stage of processing for shape from shading that requires top-down attention to the object.

Predicted Result: Active viewing will produce a larger N2 component for 3D vs 2D shape. This effect will not be present during passive viewing. This effect to be lateralised to the right hemisphere[4].

Methodology

Participants

34 participants (19 females) aged between 18 and 29 years old. All participants were right-handed with normal or corrected to normal vision.

Stimuli

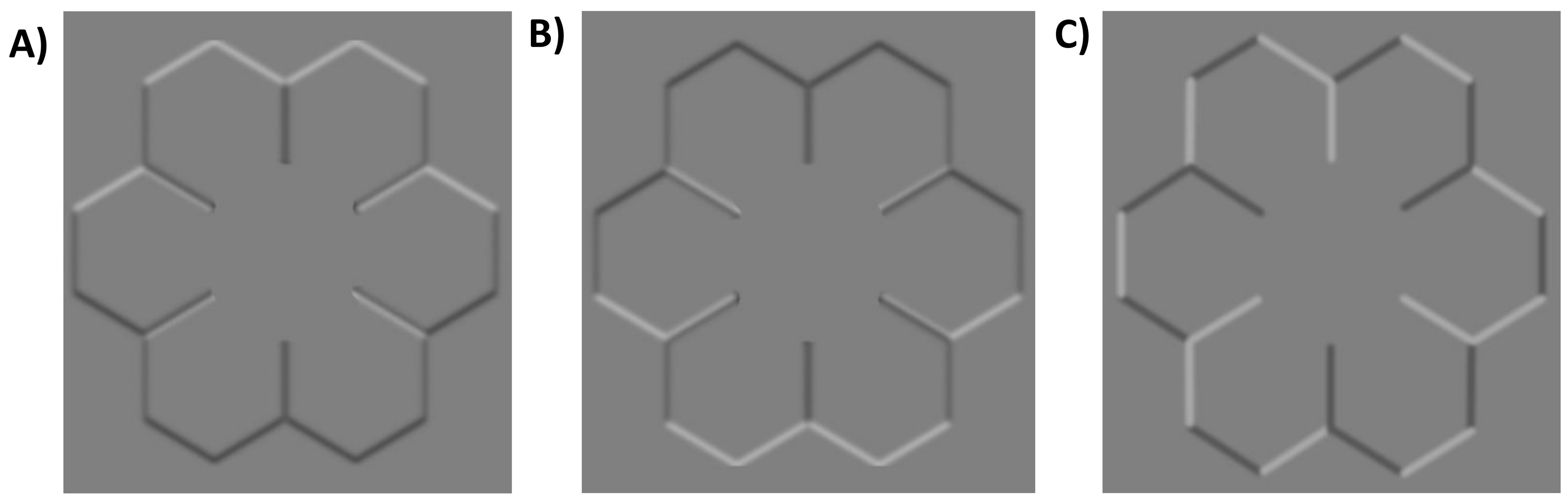

Figure 1: The snowflake stimuli used to elicit the perception of 2D and 3D shape. A) The snowflake stimulus perceived as convex (0° orientation). B) The snowflake stimulus perceived as concave (180° orientation). C) The snowflake stimulus with alternating light and dark lines, perceived as 2D.

Passive & Active Viewing Task

Participants were instructed to ignore the stimuli that proceeded a colour search task in the first half of the experiment. They were then told to attend to the 2D/3D stimuli that proceeded the colour task during the second half of the task.

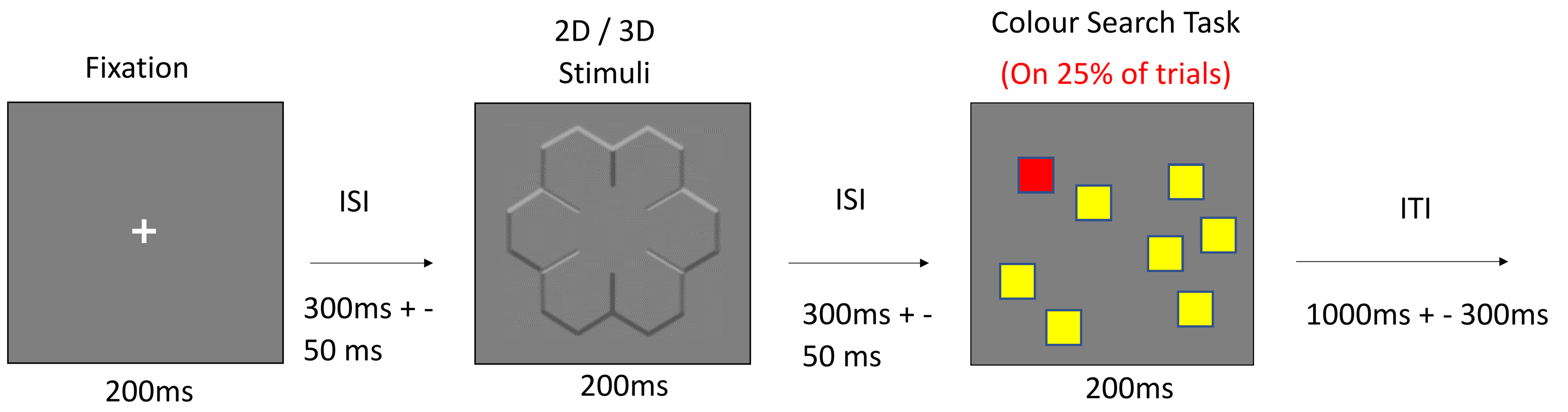

Figure 2: Demonstrating the experimental paradigm. *ISI* = inter-stimulus interval, *ITI* = inter-trial interval, *ms* = milliseconds.

Results

Passive Viewing

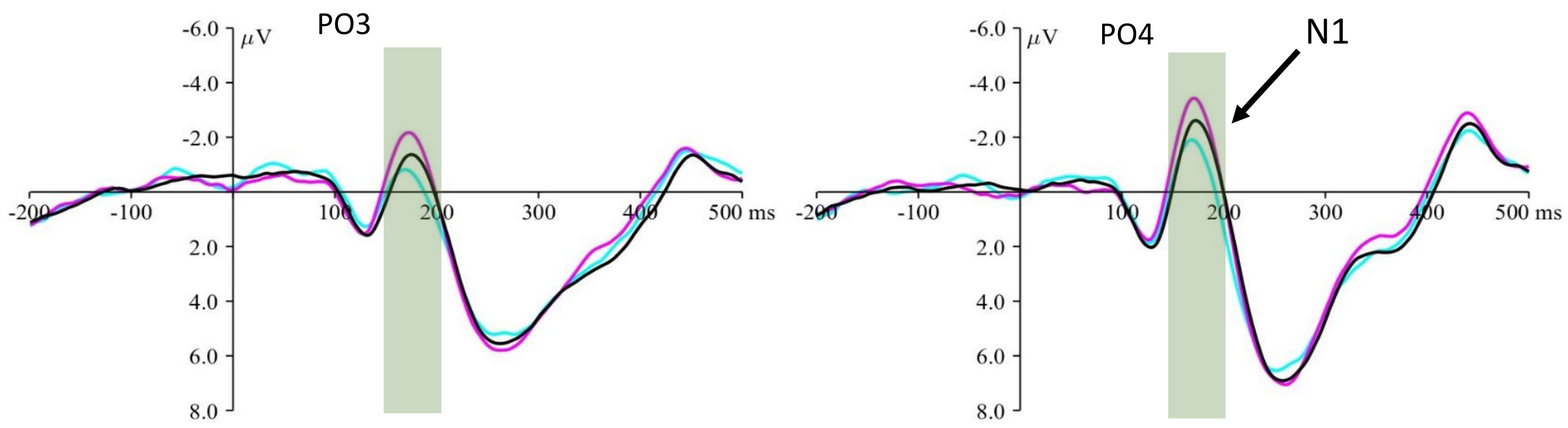

Figure 3: ERPs during passive viewing, showing the N1 component for each shape at left (PO3) and right (PO4) hemispheric sites. *ms* = milliseconds, μV = microvolts.

The mean amplitude of the N1 component was greater for concave compared to 2D (p = .03) and convex (p < .001) stimuli. No differences between 2D and convexity were found (p > .05).

Active Viewing

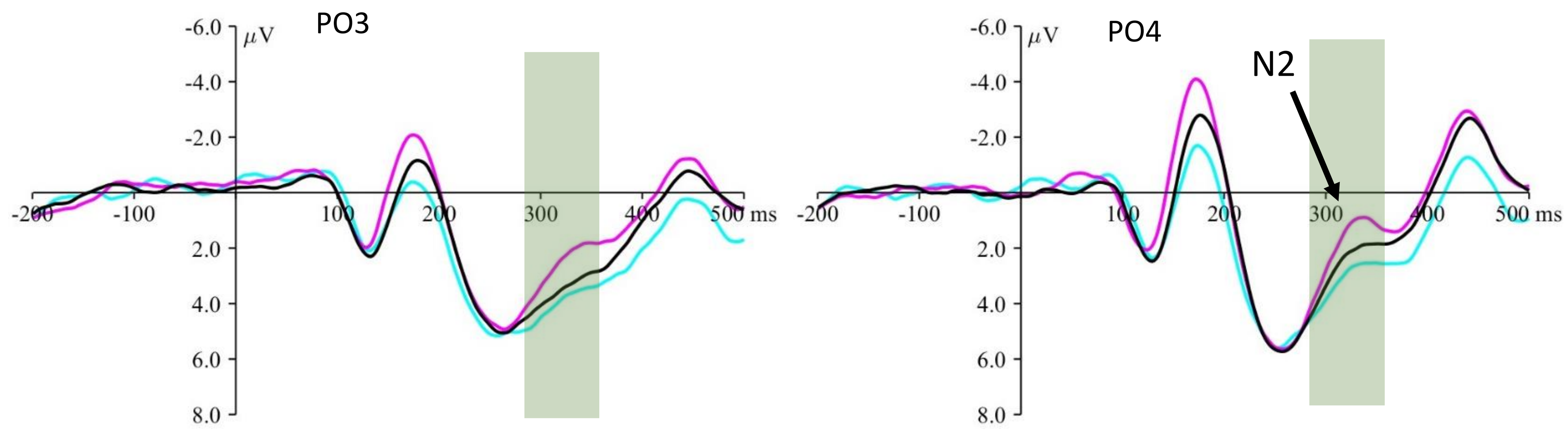

Figure 4: ERPs during active viewing, showing the N2 component for each shape at left (PO3) and right (PO4) hemispheric sites. *ms* = milliseconds, μV = microvolts.

Concave stimuli elicited a larger amplitude N2 component compared to 2D (p = .02) and convex (p = .01) stimuli. N2 amplitude did not significantly differ between convex and 2D stimuli (p > .05).

Hemispheric effects: Posterior N1 Component

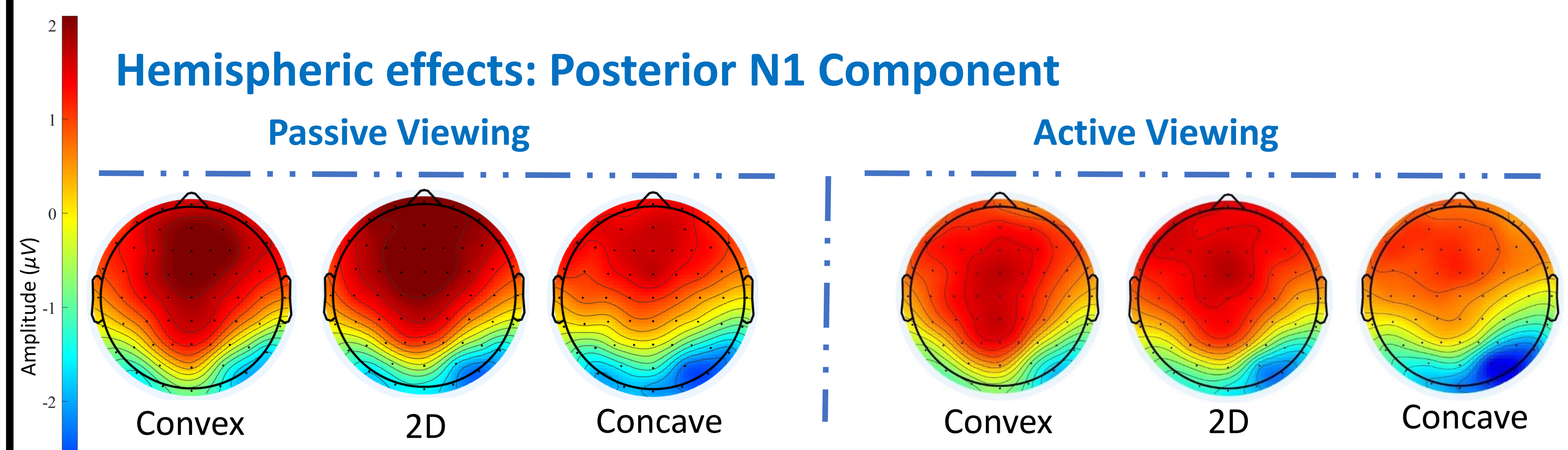

Figure 5: Topographical representation of the mean voltages across the scalp during the time range of the N1 component (150 – 200ms) in passive and active viewing. μV = microvolts.

There was no asymmetry or laterality of the N1 component during passive viewing (all p > .05). The N1 component was larger over the right than left hemisphere during active viewing (p = .02). This was accompanied by an effect of laterality (p = .006), reflecting larger differences between concave vs 2D and convex stimuli in the right compared to the left hemisphere.

Hemispheric effects: Posterior N2 Component

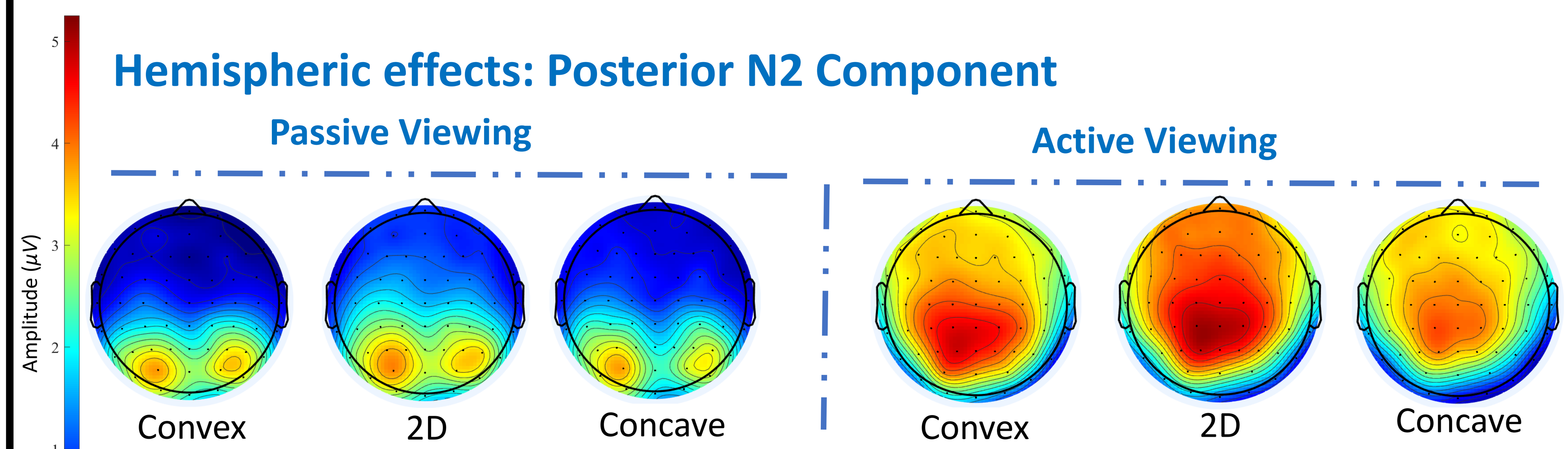

Figure 6: Topographical representation of the mean voltages across the scalp during the time range of the N2 component (290 – 350ms) in passive and active viewing. μV = microvolts.

We found no asymmetry of the N2 component during passive viewing (p > .05), whilst the N2 component was larger at right hemispheric sites during active viewing (p = .04). There was no evidence for a lateralisation of the N2 component during passive or active viewing (p > .05).

Discussion

- There is early processing related to shape from shading that occurs without the need for top-down attention, which may reflect segregation of the object from the background[3].
- This early processing becomes lateralised to the right hemisphere when top-down attention is deployed to the object.
- A later stage of processing related to shape from shading only occurs when attention is guided to the stimuli, possibly related to the disambiguation of 3D shape[3].
- These effects were observed with concave, but not convex stimuli. This may be explained by a convexity prior in shape from shading[5,6].

References

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