Target gamma response in visual ERPs

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Introduction

Gamma activity in the human EEG is assumed to represent visual binding mechanisms (Tallon et al. 1996). However, attentional processes have also been found to be correlated with EEG-gamma activity (Basar-Eroglu & Basar. 1991 , Tiitinen et al. 1993, Marshall et al. 1996, Shibata et al. 1999, Herrmann et al. 1999). In this study, we want to demonstrate that gamma activity in a visual classification task represents both, visual binding and attentional processes, however at different points in time.

We examined event-related potentials (ERPs) and gamma range EEG activity in two experiments in which subjects performed a visual classification task. Subjects silently counted the occurrence of rare targets embedded in frequent standards. We adapted the triangular Kanizsa stimuli of Tallon-Baudry et al. (1996) and added square stimuli to differentiate the processing of illusory figures and targets. The stimuli were two Kanizsa figures composed of either three or four pac-men and two non-Kanizsa figures composed of the same pac-men with different orientation such that no illusory figure was visible.

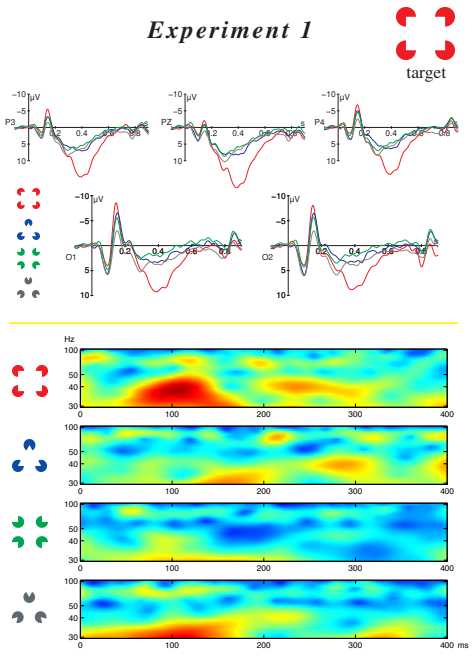
Methods

Stimuli were composed of either three or four pac-men (see results) and were presented for 700 ms on a computer screen. EEG was recorded with NeuroScan amplifiers (DC to 70 Hz, 500 Hz sampling rate, 19 electrodes). A wavelet analysis was applied to compute time-frequency diagrams and the 40 Hz activity was extracted for statistical analyses (Herrmann et al. 1999). ERPs were low-pass filtered at 20 Hz. Repeated measures ANOVAs were computed with the factors topography (anterior, posterior), figure (Kanizsa, non-Kanizsa) and form (3 or 4 pac-men). All four stimuli were equally probable. Targets had a probability of p=0.25 and standards of p=0.75. A total of 400 stimuli were presented.

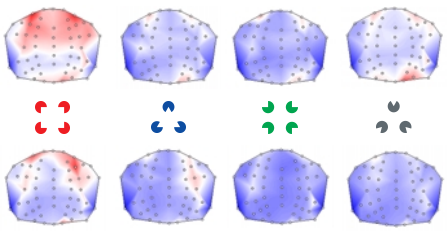
In Experiment 1 the Kanizsa square served as target stimulus. In a second experiment we changed the task to make the non-Kanizsa square the target. In both Experiments the subjects counted the target stimuli.

Results

Experiment 1



early gamma 50 .. 150 ms



late gamma 200 .. 300 ms

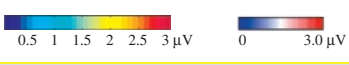
ERPs:

In both experiments, the N170 was largest for the Kanizsa square. The second largest N170 was evoked by the Kanizsa triangle and the non-Kanizsa square was larger than the N170 for the non-Kanizsa triangle, which was smallest. This did not change change between experiments. Target stimuli in both Experiments evoked a broadly distributed P300 which however was delayed for 50 ms and smaller in amplitude in Experiment 2.

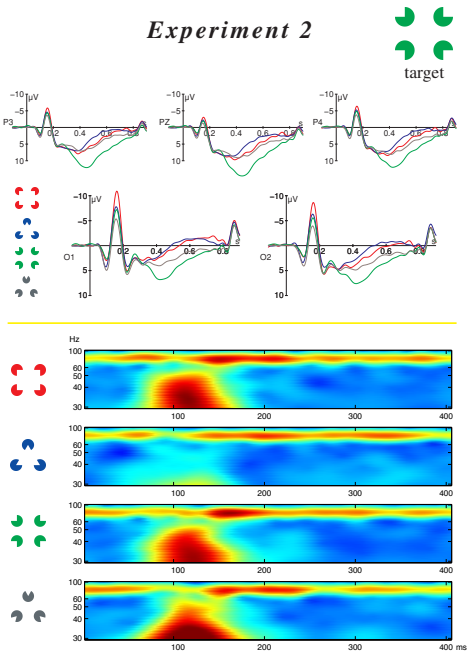
Gamma:

We found two different types of gamma responses to Kanizsa figures: an early phase-locked gamma response at 40 Hz in the N170 time range and a late phase-locked gamma activity (200-300 ms) at 40 Hz. In experiment 1, the early gamma response was largest for the target stimulus while the late gamma response was more pronounced for both Kanizsa figures than the non-Kanizsa figures. In experiment 2, we found an early phase-locked gamma response which was higher for the target and the two target-like stimuli which share one feature of the target (rectangularness/non-figureness). In addition, there was a late gamma response which was larger for Kanizsa figures than non-Kanizsa figures.

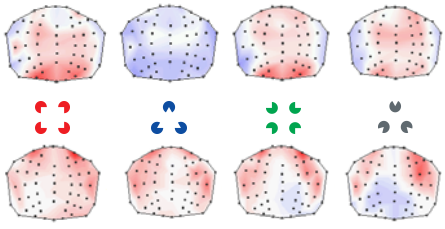
The topography of the early and late gamma response showed a frontal maximum in experiment 1. In experiment 2 the early gamma response showed a posterior distribution while the late one was again more anteriorly distributed.



Experiment 2



early gamma 50 .. 150 ms



late gamma 250 .. 350 ms

Discussion

The results of both experiments suggest a dissociation of early brain responses: while the N170 is sensitive to the combination of illusionary and physical features (Kan sq > Kan tri = non Kan sq > non Kan tri) the early gamma response is affected by top-down processes guiding the discrimination process. This is evidenced by the fact that largest gamma responses were found for target stimuli irrespectively of their physical constituents.

The late gamma component was higher for Kanizsa figures than non-Kanizsa figures in both experiments and seems to be specific for detecting illusonary contours.

Conclusion

Even though it has been argued that early gamma responses are purely sensory in origin (Karakas & Basar, 1998), we clearly demonstrated that targetness can influence this response.

Summarizing the two experiments, the early gamma response seems to be related to object attention and the late to the processing of illusory figures.

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