Diverting attention suppresses human amygdala responses to faces

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Introduction

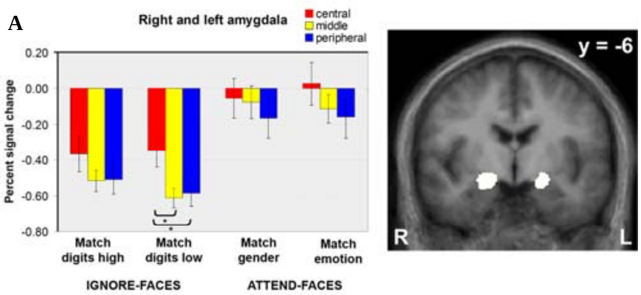
The amygdala plays an important role in the processing of emotion-laden visual stimuli[1-3] but recent neuroimaging studies disagree as to whether this is dependent upon the availability of attentional resources[4-8] or entirely capacity-free[9-11]. Two main factors have been proposed for the discrepancies: differences in the attentional demands of the tasks used to divert attentional resources from emotional stimuli and the spatial location of the affective stimuli in the visual field[12]. The present study aimed to directly test the impact of attentional load and stimulus location on the processing of emotion in the amygdala within the same group of participants using functional MRI.

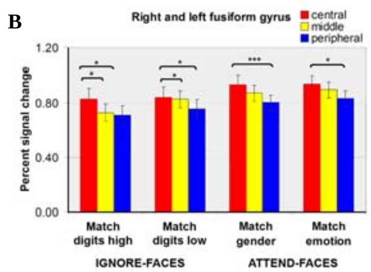
Methods

14 healthy volunteers (mean age: 25.8 years, 9 males) participated in the study. BOLD fMRI was performed at 3 Tesla (Siemens TRIO, whole-brain-EPI, TR 2s, TE 36ms, 2x2x4mm³). The visual stimuli consisted of letters and digits displayed in rapid serial visual presentation (RSVP; each stimulus for 183ms). Four RSVP streams were presented simultaneously; one peripheral stream was placed in each visual field quadrant (8.5° from central fixation). In addition, pairs of faces from the Karolinska Directed Emotional Faces[13] set were presented for 550ms at three different positions along the horizontal meridian of the visual field (central position: 1.68° from central fixation, height: 3°; middle position: 5.6° from central fixation, height: 5°; peripheral position: 11.25° from central fixation, height: 7°). The photographs were scaled by the human cortical magnification factor to activate an approximately equivalent portion of early visual cortex at all stimulated eccentricities[14]. The spatial positioning of the emotional faces remained the same during the stimulation blocks, but was varied in between experimental runs. The experiment consisted of four conditions: Match digits low, Match digits high, Match gender and Match emotion. In ignore-faces trials (Match digits low and Match digits high), participants had to attend to the RSVP streams and perform two different tasks of low and high perceptual load. In the Match digits low task (low-load condition) subjects had to maintain fixation on the fixation cross, and monitor one peripheral stream of digits and letters (lower left) for a predefined target which appeared every 1800-2000ms. The other RSVP streams served as distractors. Different digits were defined as targets, which were constant within a run but varied between runs. In the Match digits high task (high-load condition) subjects had to monitor two peripheral streams in opposing visual field quadrants for the simultaneous appearance of digits and indicate via button press whether the digits were the same (match) or different (mismatch). In attend-faces trials (Match gender and Match emotion), subjects were required to perform an indirect or direct emotional processing task. In the indirect task (Match gender), subjects were instructed to maintain fixation on the fixation cross in the middle of the screen and indicate via button press whether the presented faces matched in gender or not. The direct task (Match emotion) required participants to identify the facial expression as fearful or happy, and press a button to indicate whether both faces showed the same expression or different ones. Neutral faces only served as distractors. A blocked design was used, altering between tasks (20s) and a fixation condition (20s). The effects of attentional load and the spatial position of emotional stimuli on amygdala activity were investigated by performing a region-of-interest (ROI) analysis. To ascertain the reliability of the attentional-load manipulation, we defined another ROI in the fusiform gyrus.

Results

Overall, the results revealed a strong attenuation of amygdala activity with higher attentional load. Suppressed amygdala responses were observed during all task conditions, compared to the fixation condition. **Figure A** plots the average maximum percent signal change for all task conditions and for the three positions of the face stimuli in the amygdala and shows the defined ROI. The results revealed a strong dependence of amygdala responses on the allocation of attention as the two ignore-faces conditions caused a significant suppression of responses compared to the two attend-faces conditions. However, responses in the amygdala were not affected by stimulus location. **Figure B** plots the average maximum percent signal change for all task conditions and for the three positions of the face stimuli in the fusiform gyrus. The fusiform gyrus activation was larger in all attend-faces conditions compared to the ignore-faces condition. The contrast between the attend-faces conditions resulted in no significant difference, and within the ignore-faces conditions only the middle location showed a significant effect. Furthermore, the response in the fusiform gyrus was differentially affected by the spatial location of the faces. Within all task conditions, an increase of activation in the fusiform gyri was observed with decreasing eccentricity.





Conclusion

Responses in the human amygdala to emotional stimuli strongly depend on the availability of attentional resources, whereas the spatial location of the stimuli does not significantly affect responses. Demanding cognitive tasks that withdraw attention from the emotional stimuli are associated with an active suppression of amygdala responses elicited during a default state, which is suspended during many types of cognitive processing[15,16]. Thus, the decreased activity during the active tasks may reflect the absence of processes that occur during neutral or passive conditions. This implies that the preferential activation of the amygdala by emotional facial expressions may not only depend on attention to the faces, but instead may require that no suppression processes are active at the time of stimulation. In summary, our data suggest that the processing of emotional information in the amygdala is governed by top-down processes involved in selective attention. This is reminiscent of the strong dependency of responses across visual cortex on attentional allocation to the respective visual stimuli. The observed modulation of amygdala responses by attention will contribute to the generation of an integrated saliency map[17] in which the strength of representation of an emotional stimulus is a combination of its emotional valence ('salience') with the behavioural context in which attention can be allocated or diverted from the stimulus.

References

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