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DIFFERENTIAL AMYGDALA ACTIVATION DURING SIMULATED PERSONAL SPACE INTRUSION BY MEN AND WOMEN

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Abstract—Responses to personal space (PS) violations are variable and depend (besides many other factors) on the sex of the person who enters this space. The neuronal basis of this effect is still largely unknown. A previous neuroimaging investigation had shown that male participants responded with increased amygdala activation to PS violation, but only when the intruder was male. Gender-specific responses by females have not been studied yet. In the present study we recorded affective as well as hemodynamic responses of 30 women (mean age: M = 27.3 years; SD = 8.1). The participants were exposed to images of neutral facial expressions from men and women. All stimuli were once shown as photos (static), and once were zoomed in (picture enlargement by the factor 2.75) in order to simulate PS intrusion. In both conditions ('static' and 'approaching' faces) the eyes and mouth region of the depicted persons were always completely visible. Approaching faces generally provoked activation of a parietal network (e.g., intraparietal sulcus, superior/inferior parietal cortex). When the approaching person was male additional amygdala activation was detected. Because the amygdala is a central structure for the initiation of defense responses, the heightened activation might reflect that male intrusion was decoded as potential threat. Hence, we observed a similar gender bias to simulated space intrusion in women as previously in men.

Key words: personal space, fMRI, amygdala, parietal regions.

INTRODUCTION

The region immediately surrounding our bodies constitutes the (peri)personal space (PS; Holmes and Spence, 2004; Graziano and Cooke, 2006). It is a safety zone, and whenever a stimulus approaches or enters it, defensive reactions are primed. Neuroimaging investigations have shown that PS intrusion by another person leads to amygdala activation (e.g., Schienle et al., 2015). Moreover, a patient with a complete bilateral amygdala lesion lacked any sense of PS (Kennedy et al., 2009). The amygdala is a central structure for the initiation of defense responses (LeDoux, 2014) and by that mediates self-protection.

In addition, PS processing is associated with activation of visuo-tactile neurons in the parietal cortex, the putamen and the premotor cortex as demonstrated by a convergent series of studies in animals and humans (Graziano and Cooke, 2006; Brozzoli et al., 2012). These studies showed that spatial proximity recruits brain areas which are sensitive to touch. Not only actual touch, but also the observation of another person being touched, or another person coming closer, recruits touch-sensitive neurons (e.g., Schaefer et al., 2012; Schienle et al., 2015, 2016).

Interestingly, PS is a dynamic perception which is influenced by different moderating variables such as the sex of the approaching person. When participants are asked to draw a PS bubble around a silhouette representing their own person it is a consistent finding that women prefer greater interpersonal distance to the opposite sex compared to men (e.g., Schienle et al., 2015). This effect can also be shown when a behavioral technique, the stop-distance task, is used (e.g., Miller et al., 2013; Holt et al., 2014). Here, the experimenter slowly approaches the participant until he/she starts to feel uncomfortable and indicates not to come closer anymore. The remaining distance indexes PS size.

One method to simulate PS intrusion during neuroimaging experiments is the presentation of stimuli that are gradually enlarged. Holt et al. (2014) showed images of faces that were expanded to evoke the impression that the displayed person was coming closer. The preferred distance to a man relative to a woman in the stop-distance task was positively correlated with parietal activation during simulated intrusion. Surprisingly, gender differences (approaching men vs. women) for the simulation had not been tested directly. This was done in a functional magnetic resonance imaging (fMRI) study by Schienle et al. (2016) with exclusively male participants. Here, amygdala recruitment was only seen when the approaching person was male. To the best of our knowledge it has not been investigated whether a similar gender bias to simulated space intrusion exists in women.

Therefore, in the present fMRI investigation PS intrusion by men and women was simulated. Pictures of neutral facial expressions were enlarged (zoomed-in) to make the person appear coming closer (almost touching). Half of the presented posers were women,

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Abbreviations: fMRI, functional magnetic resonance imaging; GM, gray matter; IPS, intraparietal sulcus; PPD, Preferred Personal Distance; PS, personal space; ROI, region of interest; WM, white matter.

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the other half men. The reactions to the 'approaching' faces were contrasted with a control condition using the same pictures, but without animation (static). Furthermore the hemodynamic responses of the participants were correlated with their preferred distance to a female and a male as indexed by a drawn PS bubble. We hypothesized that the female participants would respond with increased activation in PS-relevant brain areas (e.g., parietal cortex) toward simulated PS intrusion relatively to static pictures. The activation should be positively correlated with the preferred distance to a person. Moreover, we expected increased amygdala responses to simulated male intrusion.

EXPERIMENTAL PROCEDURES

Sample

We investigated 30 healthy women with a mean age of 27.3 years (standard deviation = 8.1); the majority were university students (70%), the rest were white-collar employees. The participants did not suffer from mental or somatic disorders and did not take medication as insured by a standardized clinical interview (Margraf, 1994). All participants provided written informed consent after receiving full explanation of the test procedure. The study had been approved by the ethics committee of the University of Graz.

Procedure and materials

During the fMRI session, the participants passively viewed pictures of facial expressions. They were instructed to lie still in the scanner and to pay attention to the presented images. We administered 32 pictures from the Karolinska Directed Emotional Faces (Lundqvist et al., 1998) that showed neutral facial expressions. Half of the posers were men, the other half women. Each picture was presented for 3000 ms once 'static' and once 'approaching' in an event-related design. In the latter condition the original picture was enlarged (factor: 2.75) up to point that only the region involving the mouth and the eyes could be seen. This gave the impression that the approaching person almost touched oneself. During the inter-stimulus interval, which was jittered between 2500 and 3000 ms, a fixation cross was presented. All images were shown twice in randomized order. The total experiment lasted approximately 6 min.

Subsequent to the MRI experiment the participants rated valence and arousal (1 = calm, positive; 9 = aroused, negative) for a random selection of the presented images (half male, half female) outside of the scanner. They rated eight pictures of each condition.

Finally, the participants were presented with a silhouette of a female person representing the participant (height: 50 mm; width: 13 mm). Participants were asked to draw a bubble around the silhouette (which represented herself) in order to indicate the distance she would like to maintain between herself and another man and another woman (strangers; e.g., sales woman/man). The bubble diameter (in mm) was considered the Preferred Personal Distance (PPD). A pilot study with a two-week interval indicated retest reliabilities ranging between .79 and .84 for this measure.

fMRI acquisition and preprocessing

The fMRI session was conducted with a 3-T scanner (Skyra, Siemens, Erlangen, Germany) using a 32-channel head-coil. Functional images were acquired using an echo-planar imaging protocol (number of slices: 35, descending, flip angle = 90°, slice thickness: 3 mm, distance factor: 33%, resulting in a covered volume in feet-head direction of 139 mm; TE = 30 ms; TR = 2290 ms; matrix: 64 × 64; FoV: 192 mm; in-plane resolution = 3.0 × 3.0 mm). Structural T1-weighted images were obtained using a 3D-MPRAGE sequence (number of slices: 176, ascending, TE = 2.07 ms; TR = 1560 ms; flip angle = 9°; slice thickness: 1 mm; FoV: 256 mm; distance factor: 50%).

All analyses were conducted using SPM8 (Wellcome Department of Cognitive Neurology, London). Three volumes from the beginning of the time series were discarded to account for saturation effects.

First functional data were motion corrected via realignment and acquisition timing was accounted in the slice timing step. Individual T1-weighted images were coregistered to their functional data. Afterward coregistered T1-weighted images got 'segmented' into gray matter (GM), white matter (WM) and cerebrospinal fluid. To create a study specific template and to increase inter subject alignment GM and WM images were used in a 'Fast Diffeomorphic Registration Algorithm' (DARTEL). Resulting images were further normalized to MNI-space (3 mm isotropic voxel), and smoothed with an 8-mm isotropic Gaussian kernel. In the first-level analysis the six movement parameters obtained during the realignment step were used as regressors of no interest.

Statistical analyses

In the first-level analysis t-contrasts of the interactions were built for each participant. We compiled vectors for each event of interest (e.g., Approaching_Neutral_Man, Static_Neutral_Female) and entered them into the design matrix to model event-related responses by the canonical hemodynamic response function in the first-level stage. Data were high-pass filtered (128 s). To account for serial correlations, which can result from unmodelled neuronal activity and biorhythms we applied an AR(1) process.

In the second level, we computed an analysis of variance with GLM-Flex (http://mrtools.mgh.harvard.edu/index.php/Main_Page) with the factors Motion (approaching, static) and Poser sex (male, female). Statistically significant main effects and interaction effects were followed up by one-dimensional t-contrasts. Further, PPD scores were correlated with region of interest (ROI) activation in a multiple regression analysis. The uncorrected cluster-building threshold for the analyses was set to $p < 0.05$, with at least 20 contiguous voxels. We conducted exploratory whole-brain voxel intensity tests as well as ROI analyses for