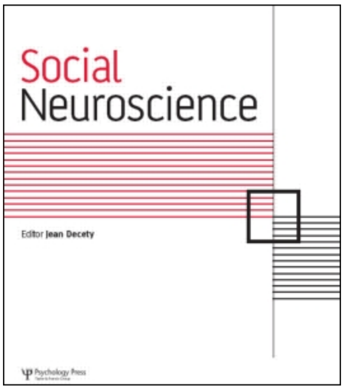

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Amygdala activation during recognition of emotions in a foreign ethnic group is associated with duration of stay

Birgit Derntl [ab]; Ute Habel [bc]; Simon Robinson [cd]; Christian Windischberger [c]; Ilse Kryspin-Exner [e]; Ruben C. Gur [f]; Ewald Moser [cf]
[a] Medical University of Vienna, and University of Vienna, Vienna, Austria [b] RWTH Aachen University, Aachen, Germany [c] Medical University of Vienna, Vienna, Austria [d] University of Trento, Mattarello, Italy [e] University of Vienna, Vienna, Austria [f] University of Pennsylvania Medical School, Philadelphia, Pennsylvania, USA

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Amygdala activation during recognition of emotions in a foreign ethnic group is associated with duration of stay

Birgit Derntl

Medical University of Vienna, and University of Vienna, Vienna, Austria, and RWTH Aachen University, Aachen, Germany

Ute Habel

Medical University of Vienna, Vienna, Austria, and RWTH Aachen University, Aachen, Germany

Simon Robinson

Medical University of Vienna, Vienna, Austria, and University of Trento, Mattarello, Italy

Christian Windischberger

Medical University of Vienna, Vienna, Austria

Ilse Kryspin-Exner

University of Vienna, Vienna, Austria

Ruben C. Gur

University of Pennsylvania Medical School, Philadelphia, Pennsylvania, USA

Ewald Moser

Medical University of Vienna, Vienna, Austria, and University of Pennsylvania Medical School, Philadelphia, Pennsylvania, USA

Cultural differences in emotion recognition performance have frequently been reported, whereby duration of stay in a foreign culture seems to be a crucial factor. Furthermore, cultural aspects influence the neural correlates of face and emotion processing thereby also affecting the response of the amygdala. Here, the exposure to a foreign culture and its influence on the cerebral correlates of facial emotion recognition were examined in 24 Asian and 24 age-matched European males. Subjects performed an explicit emotion recognition task and were imaged with a 3 T MR-scanner. Results demonstrate a significant cultural influence on the specific recognition of disgust and anger, with higher accuracy among the Europeans, while the functional data indicate generally elevated amygdala activation in Asians compared to Europeans. Moreover, a significant inverse correlation between duration of stay and amygdala response emerged, with stronger activation in those subjects with shorter duration of stay in Europe. The observed amygdala hyperactivation in Asians may reflect novelty aspects but might also be associated with greater effort and motivation in immigrants, thus it possibly reflects one neural correlate

Correspondence should be addressed to: Ewald Moser, Centre for Biomedical Engineering and Physics, Medical University of Vienna, Währingerstrasse 13, 1090 Vienna, Austria. E-mail: ewald.moser@meduniwien.ac.at

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of the ‘‘alien-effect’’. We conclude that exposure to a foreign culture and duration of stay affect the behavioral and neural response to facial expressions of emotions.

Keywords: Culture; Facial expressions; Emotions; Amygdala; fMRI; Alien-effect.

INTRODUCTION

Cultural differences in neural activity have been reported for both high-level cognition (e.g., theory of mind; Kobayashi, Glover, & Temple, 2006), and low-level cognition (e.g., perception; Lin, Lin, & Han, 2008) (for review see Han & Northoff, 2008). Regarding emotion processing, previous findings from cross-cultural studies indicate that people generally have more difficulties in understanding facial expressions and nonverbal, communicative behavior of individuals from foreign countries and continents. Consequently, Marsh, Elfenbein, and Ambady (2003) propose the term of nonverbal ‘‘accents’’ and Elfenbein and Ambady (2002) describe the ‘‘alien-effect’’, whereby people who have just moved to live with another ethnic group show initial difficulties in accurately recognizing emotions in the faces of members of this new group. Such restricted competency hinders adequate social interaction and consequently complicates social integration of the immigrants. This raises the important question as to whether this alien-effect might be explainable by differential activation patterns in the facial emotion recognition network. However, Elfenbein and Ambady (2002) also reported that after about two years spent in the foreign country these initial difficulties diminish, characterized by significantly improved accuracy indicating successful acclimatization and adaptation to the new host country.

The neural substrates of facial emotion recognition are well studied (e.g., Adolphs, 2002) and a crucial role falls to the amygdala. Amygdala activation has been observed for the processing of all facial expressions of emotions (Derntl, Kryspin-Exner, Fernbach, Moser, & Habel, 2008a; Fitzgerald, Angstadt, Jelsone, Nathan, & Phan, 2006; Yang et al., 2002), and irrespective of task instructions (Gur et al., 2002a; Habel et al., 2007).

Some functional imaging studies have investigated cultural aspects of the processing of neutral faces, pointing to significant differences in amygdala activation: Hart and colleagues observed a significant habituation in amygdala response in both groups (African American (AA) and Caucasian American (CA) males) to the presentation of in-group faces, while response to out-group faces was sustained (Hart et al., 2000). Using unfamiliar AA and CA faces, Phelps et al. (2000) reported a significant correlation between left amygdala response to AA faces in Caucasian subjects and indirect measures of race evaluation. Moreover, subliminally (30 ms) presented stimuli elicited stronger right amygdala activation for AA faces in the CA group than consciously processed AA faces, indicating a significant impact of awareness on amygdala activation (Cunningham et al., 2004).

Again, using neutral facial expressions of AA and CA males, Lieberman, Hariri, Jarcho, Eisenberger, and Bookheimer (2005) demonstrated a greater response of the right amygdala region to AA faces in both CA and AA subjects in a perceptual encoding condition. As an explanation the authors referred to the functionality of the amygdala, which is known to respond to novel (Wright et al., 2003) and threatening stimuli; however, amygdala differences occurred only for unfamiliar AA faces in both subject groups.

Emotional expressions (happy and fearful) have been used only twice in a functional magnetic resonance imaging (fMRI) study addressing cultural impact: Moriguchi et al. (2005) showed differences in the neural processing of fearful faces between Caucasian and Japanese subjects that also seemed to affect the amygdala response. Caucasians exhibited a significantly greater activation of the left amygdala during presentation of fearful faces than Japanese subjects, and the authors suggest that the threatening effect of these facial stimuli varied between cultures, with Caucasians demonstrating a stronger reaction. However, differences in amygdala response were seen only using a very low threshold, probably due to methodological limitations, i.e., low sensitivity. Furthermore, some of the Caucasian subjects had been to Japan for a longer time period (maximum: 11 years), hence an impact of adaptation cannot be ruled out. Recently, Chiao et al. (2008) presented emotional expressions of Japanese and Caucasian actors to Japanese and Caucasian Americans and observed significantly elevated amygdala response to in-group expressions of fear in both groups, indicating a specific sensitivity of the amygdala to optimally respond to facial expressions of fear specific to one's own cultural group.

The present study examined recognition accuracy and amygdala activation during an explicit emotion recognition task in Asian immigrants (exchange students with a short residence time in Austria) and Europeans (Caucasian Austrians), thereby allowing investigation of initial difficulties in emotion identification and their possible impact on amygdala response. We chose exchange students for several reasons as these samples are not affected by age effects, have similar educational background and finally, these are subjects that visit another culture and country for a limited time on a voluntary basis. We applied an optimized high-resolution fMRI protocol for reliably detecting amygdala activation (Robinson, Windischberger, Rauscher, & Moser, 2004; Robinson et al., 2005; Robinson, Pripfl, Bauer, & Moser, 2008) to investigate the influence of culture and emotions on behavioral performance and lateralized neural response.

The heterogeneity of previous findings on cultural aspects of face processing raises questions that might stimulate further research due to remarkable heterogeneity with respect to laterality and in-group or out-group effects that still lack comprehensible interpretation.

Based on previous findings (e.g. Derntl et al., 2008b; Fitzgerald et al., 2006; Habel et al., 2007) and in light of its evaluation and relevance detection function (e.g. Sander, Grafman, & Zalla, 2003) we hypothesized significant amygdala response to all emotions in both samples. Furthermore, according to previous results showing a stronger or less habituated amygdala response to out-group faces (Hart et al., 2000; Lieberman et al., 2005; Phelps et al., 2000) we hypothesized neural differences between groups, with Asians demonstrating sustained amygdala activation to Caucasian faces. Considering previous results on the "alien-effect" and the significant effect of duration of stay on emotion recognition performance (Elfenbein & Ambady, 2002), we further hypothesized an association between duration of stay and behavioral performance as well as the underlying neural network, in particular amygdala activation.

METHODS AND MATERIALS

Sample

Twenty-four right-handed healthy males aged 22–34 years (mean age 29.2 years, $SD = 4.4$) from Pakistan ($n = 11$, mostly from the city of Lahore), India ($n = 1$, from the border region between Pakistan and India), China ($n = 9$) and Japan ($n = 3$) formed the Asian group. Since our subjects not only had another nationality and ethnical background but also differed in noncultural ecological factors such as religion (see Matsumoto & Yoo, 2006 for a discussion on the definition of culture and cultural factors) we split them into an East Asian group ($n = 12$, China + Japan) and West-South Asian group ($n = 12$, Pakistan + India). A divergence between Pakistan/India and China/Japan has also been observed by Hofstede (2001); in particular these nations differed in long-term orientation (China/Japan have high values (> 90%) whereas Pakistan and India are below 10%), which has been the best predictor of country differences in emotional expressivity (Matsumoto et al., 2008) and emotional experience (Matsumoto, Nezlek, & Koopmann, 2007).

An important inclusion criterion for the Asian subjects was duration of stay: All Asian subjects have not been in Europe for longer than one year (mean: 6.1 months, $SD = 3.3$; minimum: 1 month, maximum: 12 months) and spoke English fluently. Twenty-four right-handed healthy Austrian males aged 20–35 years (mean age 28.3 years, $SD = 3.3$) represented the European group. Subjects were recruited via advertisements posted at the University of Vienna and the Medical University of Vienna. All subjects were financially reimbursed for their participation and written informed consent was obtained. The study was approved by the local ethics committee and subjects were treated according to the Declaration of Helsinki (1964) regarding treatment of human research participants.

Exclusion of psychiatric disorders (according to DSM-IV) was ascertained by the Structured Clinical Interview (German version of the SCID;

Wittchen, Zaudig, & Fydrich, 1997) conducted by experienced clinical psychologists. The usual exclusion criteria for magnetic resonance imaging (MRI) were also applied. Right-handedness was assessed with the Edinburgh Handedness Inventory (Oldfield, 1971). Asians and Europeans were of similar age ($p = .262$) and years of education ($p = .589$; Asians, mean = 17.8 years, $SD = 2.4$; Europeans, mean = 17.4 years, $SD = 2.8$). All subjects completed a questionnaire measuring alexithymia (TAS 20; Bagby, Parker, & Taylor, 1994), to exclude subjects who have difficulties identifying feelings and distinguishing between feelings (alexithymic subjects). Alexithymia scores did not differ significantly between groups (TAS-20, $t(46) = 1.350$, $p = .184$; Asians: mean (SD) = 49.3 (6.2); Europeans: mean (SD) = 51.6 (9.2)). In addition, Asian and European subjects did not differ significantly in their estimated nonverbal intelligence (Raven's Standard Progressive Matrices; Van der Ven & Ellis, 2000), $t(46) = 1.527$, $p = .135$; Asians: mean (SD) = 28 (4.2); Europeans: mean (SD) = 26.4 (2.6).

Functional task

The explicit emotion recognition task consisted of 30 colored photographs of evoked facial expressions portraying the five basic emotions (anger, disgust, fear, happiness and sadness) and an equal number of neutral expressions. All expressions were taken from a stimulus set which has been standardized and used repeatedly as neurobehavioral probes in neuroimaging research (see Derntl et al., 2008a, 2008b; Gur et al., 2002a, 2002b; Habel et al., 2007; Moser et al., 2007). The stimulus material applied here was also validated for the European population (Hoheisel & Kryspin-Exner, 2005). The stimuli were balanced for valence and gender. Each actor appeared only once and all actors were Caucasians. Since we were interested in minor cultural influences reflected in initial difficulties with regard to emotion recognition in a foreign ethnic group, we did not assess recognition accuracy for in-group faces in the Asian group and acted on the assumption that emotion recognition of in-group facial expressions is a general basic ability which is a given in all ethnicities without any significant differences (for review see Elfenbein & Ambady, 2002; Matsumoto, 2002).

Stimulus presentation was randomized with regard to emotion and the order of presentation was kept constant between subjects. Subjects were instructed to choose the correct emotion from two possibilities presented on the left and right of the face by pressing the corresponding button of a response box using the right middle and index fingers as quickly as possible. One of the options was correct and the other was selected at random from the other categories (see above). Facial expressions were presented for a maximum of 5 s with a randomized, variable interstimulus interval (ISI) ranging from 12 s to 18 s (during which subjects viewed a scrambled face with a central crosshair). Manual responses triggered immediate progression to the next ISI. Stimuli were projected onto a screen and viewed by the participants via a mirror mounted on the head coil. The presentation of images, recording of responses and acquisition of scanner triggers (one per TR) was controlled with the Presentation software package (Neurobehavioral Systems, Inc., Albany, CA, USA). Pictures were presented with a resolution of 282×400 ($B \times H$) pixels yielding a visual angle of approximately $3.1^\circ \times 4.4^\circ$.

Behavioral data analysis

Statistical analyses were performed using SPSS 15.0 and, unless otherwise specified, the level of significance was set at $p = .05$ (two-tailed).

The behavioral data (emotion recognition performance and reaction times) acquired during scanning was analyzed with a repeated measures ANOVA, with emotion (anger, disgust, fear, happiness, sadness, and neutral) as within-subjects factor and ethnic group (Asian vs. European) as between-subjects factor.

To allow analysis of inter-Asian differences, participants from Pakistan and India formed the West-South Asian subsample ($n = 12$) while Chinese and Japanese males formed the East Asian group ($n = 12$). Behavioral data was analyzed applying repeated measures ANOVAs with emotion as within-subject factor and group (East Asians vs. West-South Asians) as between-subjects factor. Greenhouse-Geisser-corrected p-values were used for all ANOVAs and *post hoc* results were Bonferroni corrected.

fMRI acquisition parameters and data processing

All subjects were examined with a 3 T Medspec whole-body scanner (Bruker Biospin, Ettlingen, Germany) at the MR Centre of Excellence, Medical University of Vienna, Austria. Functional imaging was performed in the axial plane using gradient-recalled echo planar imaging (EPI). Ten oblique axial slices centered on the amygdala were acquired using asymmetric *k*-space sampling (FOV = 25 × 21 cm, matrix size 128 × 91, slice thickness 2 mm, slice gap 0.5 mm, TR = 1000 ms, TE = 31 ms, 570 volumes per run). Cardiac action and breathing were digitally recorded to allow physiological artifact correction in post-processing, which has been shown to increase the sensitivity of fMRI analyses, especially in the amygdala region (Windischberger, Friedreich, Hoheisel, & Moser, 2006).

Functional data were preprocessed using SPM2 (www.fil.ion.ucl.ac.uk/spm/spm2.html). Images were slice timing corrected, realigned to the mean image and normalized into the standardized stereotactic space. Functional data sets were spatially smoothed using an isotropic Gaussian kernel with a full-width-at-half-maximum of 9 mm for reasons of physiological and thermal noise, thereby increasing signal to noise ratio (SNR) and to allow inferences to statistical significance in the context of the Gaussian random field theory (Triantafyllou et al., 2005). For this event-related design, each stimulus was modeled with a separate regressor, based on the individual response period convolved with the canonical hemodynamic response function and its temporal derivative. This enables the calculation of contrasts for each valence. An additional box-car regressor without hemodynamic delay was used to account for signal changes due to head motion during stimulus presentation. Regressors of each emotional stimulus were pooled to assess brain responses to emotional expressions, and the same procedure was applied for neutral faces to retrieve brain response to neutral stimuli. Moreover, a contrast including all emotional stimuli minus the neutral expressions was used to separate amygdala activation towards emotional faces vs. neutral expressions. Statistical analysis was performed at the individual and group levels. To detect group differences, contrast images from all subjects were included in a second-level random effects analysis.

Region of interest (ROI) analysis

Since our main hypothesis focused on the amygdale, we performed a ROI analysis with the aim of maximizing the sensitivity to amygdala results. A further aim was to analyze possible hemispheric lateralization effects in greater detail. Note that the data sets were spatially smoothed by a Gaussian kernel of 9 mm, before whole-brain and ROI analysis, which corresponds approximately to the size of the amygdala and crucially increased SNR. Values for amygdala ROIs were extracted using a template based on the MNI single subject brain (Tzourio-Mazoyer et al., 2002), as defined in MRIcro (www.sph.sc.edu/comd/rorden/template.html). Mean parameter estimates were extracted for left and right amygdala ROI in each condition and subject using IDL (Interactive Data Language, RSI, Inc., Boulder, CO, USA). An emotion–neutral contrast was calculated pooling all emotional stimuli minus all neutral stimuli. Levene-tests for homogeneity of variances indicated homoscedasticity for the parameter estimates across all subjects (contrast: emotion–neutral) of left and right amygdala (left: $p = .334$; right: $p = .725$). A two-way ANOVA was applied with group (Asian vs. European) as between-subject factor and laterality (left vs. right amygdala) as within-subject factor. Greenhouse-Geisser corrected *p*-values are presented. To further investigate inter-Asian differences (East Asians vs. West-South Asians) two-sample *t*-tests were applied since requirements for parametric testing were fulfilled.

Corollary analyses

Correlation analysis was performed between recognition accuracy and right and left amygdala response. To analyze any influence of duration of stay a correlation analysis between months of stay in Austria and behavioral performance as well as amygdala activation was computed for the Asian sample.

For all other brain regions that were covered with our protocol, activation differences (emotion vs. neutral) between Asians and Europeans as well as inter-Asian comparisons were calculated with two-sample *t*-tests. For the whole slab analysis and direct comparisons results are presented at an uncorrected threshold of $p < .001$.

RESULTS

Behavioral data

Emotion recognition accuracy was 82.3% ($SD =$ 8.7) on average for Asian and 89.4% ($SD = 7.5$) for European subjects. The repeated measures ANOVA revealed a significant emotion effect, $F(5, 230) = 25.241$, $p < .001$, with highest accuracy for happy expressions, a significant ethnic group effect, $F(1, 47) = 9.074$, $p = .004$, with better performance by the European males, and a significant emotion-by-ethnic group interaction, $F(5, 230) = 4.574$, $p = .002$, emerged. *Post hoc* tests disentangling the significant interaction demonstrated significantly lower performance by the Asian males for anger, $p = .001$, and disgust, $p < .001$, expressions. For all other emotions no significant difference occurred (fear: $p = .253$, happy: $p = .096$, sad: $p = .781$, neutral: $p = .789$).

Analysis of inter-Asian differences in emotion recognition by applying another repeated measures ANOVA with group (East Asia vs. West/South Asia) as between subjects factor revealed a significant emotion effect, $F(5, 110) = 23.087$, $p <$ .001, again with highest accuracy for happy faces, but no significant group effect, $F(1, 22) = .203$, $p = .657$, and no significant group-by-emotion interaction, $F(5, 110) = 1.598$, $p = .186$. Figure 1 illustrates emotion recognition accuracy across Asian and European males.

Reaction times were 2.41 s ($SD = .32$) on average for Asian and 2.28 s ($SD = .45$) for European subjects. Analysis of reaction times revealed a significant emotion effect, $F(5, 230) = 32.506$, $p < .001$, but no significant ethnic group effect, $F(1, 46) = 1.316$, $p = .257$, and no significant interaction between emotion and ethnic group, $F(5, 230) = 1.958$, $p = .096$.

Analysis of inter-Asian differences in reaction time by applying another repeated measures ANOVA with group (East Asia vs. West Asia) as between-subjects factor revealed a significant emotion effect, $F(5, 110) = 19.898$, $p < .001$, with fastest responses for happy faces, but no significant group effect, $F(1, 22) = 1.264$, $p = .273$, and no significant group-by-emotion interaction, $F(5, 110) = .842$, $p = .501$.

Correlation analysis revealed a significant association between neither recognition performance and duration of stay in Austria, $r(22) =$ .048, $p = .810$, nor reaction time and duration of stay, $r(22) = .074$, $p = .731$. Separating the Asian sample by duration of stay (group 1: less than 6 months' stay in Austria, $n = 11$; group 2: more than 6 months' stay in Austria, $n = 13$) showed no significant difference in emotion recognition performance, $t(22) = -.501$, $p = .622$, nor in reaction time, $t(22) = -.118$, $p = .907$.

Correlation analyses between alexithymia scores and behavioral performance demonstrated a significant association neither with emotion recognition, $r(46) = .010$, $p = .948$, nor with reaction time, $r(46) = .035$, $p = .826$.

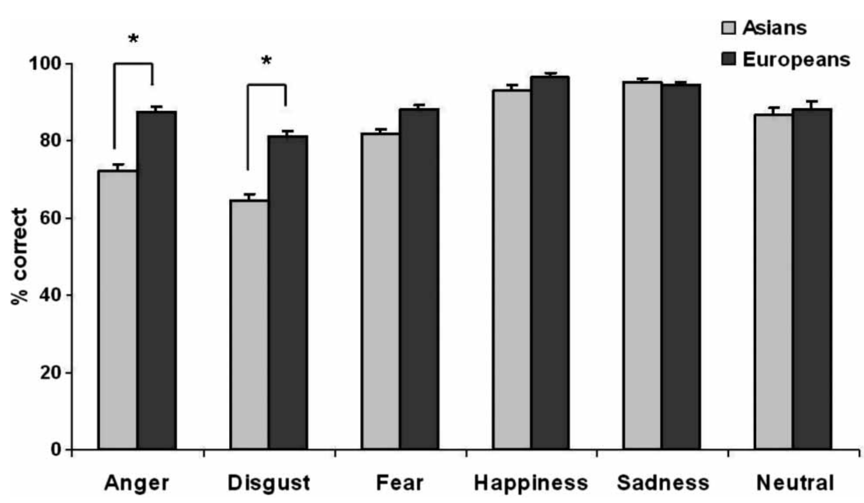

Figure 1. Behavioral performance during explicit emotion recognition task showing recognition accuracy with standard error of the mean (SEM) for all emotions. Repeated measures ANOVA revealed a significant emotion-by-ethnic group interaction indicating worse performance of the Asian group for anger ($p = .001$) and disgust ($p < .001$).

Functional data

Single-group analyses for Asian and European subjects showed bilateral amygdala activation to all presented emotions and even neutral expressions, and direct comparison between emotional vs. neutral expressions revealed significantly stronger amygdala response to emotional faces (see Figure 2).

ROI analysis

The ROI analysis demonstrated no significant laterality effect, $F(1, 46) = 1.741$, $MSE = 976.746$, $p = .194$, nor a significant laterality-by-ethnic group interaction, $F(1, 46) = .002$, $MSE = 976.746$, $p = .969$; however, a significant main effect of ethnic group emerged, $F(1, 46) = 6.722$, $MSE = 3839.172$, $p = .013$. *Post hoc* tests revealed a significant difference in neural activation between Asian and European males for left ($p = .037$) and right amygdala ($p = .015$), both times indicating stronger responses in the Asian sample.

Applying a repeated measures ANOVA to investigate inter-Asian differences, we observed no significant laterality effect, $F(1, 22) = 1.136$, $MSE = 793.527$, $p = .298$; no laterality-by-group interaction, $F(1, 22) = 2.208$, $MSE = 793.527$, $p = .151$; and no significant group effect, $F(1, 22) = 2.587$, $MSE = 5388.223$, $p = .122$.

Parameter estimates of Asian and European males of the left and right amygdala for the contrast emotion–neutral are illustrated in Figure 3.

Correlations

Correlations between recognition accuracy and neural response in the left and right amygdala region were not significant when calculated across the whole sample (left: $r(46) = -.022$, $p = .441$; right: $r(46) = -.101$, $p = .247$). Separate analyses for each ethnic group revealed only a significant correlation between emotion recognition performance and left amygdala response in the European group, $r(22) = .301$, $p = .010$; right: $r(22) = .143$, $p = .252$, whereas in the Asian group no significant correlation occurred (left: $r(22) = -.226$, $p = .144$; right: $r(22) = -.222$, $p = .149$).

Analyzing the impact of duration of stay revealed significant results for left, $r(22) = -.711$, $p < .001$, and right amygdala, $r(22) = -.605$, $p = .001$, indicating stronger amygdala response in those Asian participants with shorter duration of stay.

Figure 4 illustrates the significant correlations between amygdala response and duration of stay in the Asian group.

Correlating alexithymia scores with amygdala activation across the whole sample revealed no significant result for left, $r(46) = -.009$, p = .954, and right amygdala, $r(46) = -.127$, $p = .415$.

Whole slab analysis

Besides amygdala activation, responses of bilateral fusiform gyrus, inferior occipital and frontal gyri, inferior and medial temporal regions, hippocampus and parahippocampal gyrus as well

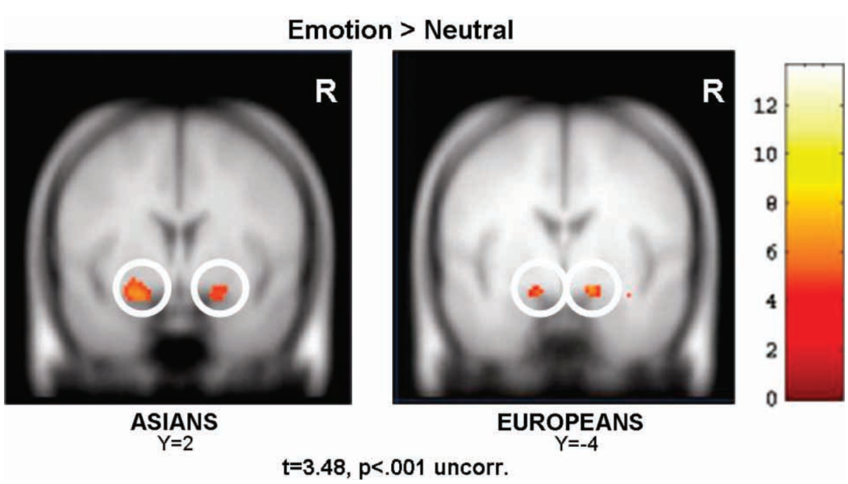

Figure 2. Results of whole-slab analysis showing activation maps of random effects analysis for all emotions minus neutral on one coronal slice comprising the amygdala for (a) the Asian sample and (b) the European sample (threshold: $p < .001$ uncorrected), and showing stronger bilateral amygdala response to emotional categories (minus neutral expressions) in both groups.

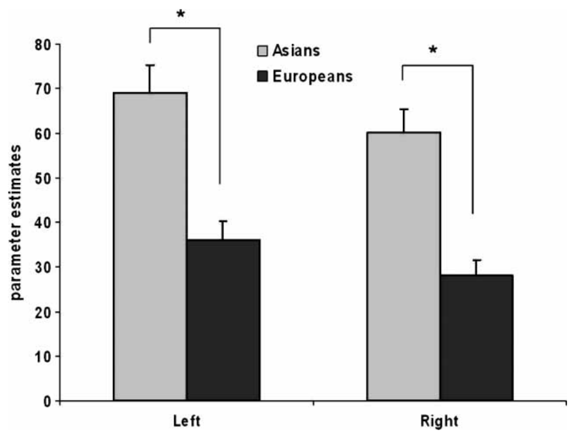

Figure 3. Results from ROI analysis showing mean parameter estimates of left and right amygdala for the emotion > neutral contrast, revealing significantly stronger left ($p = .037$) and right amygdala ($p = .015$) response in Asian males.

as brainstem and cerebellum emerged for all emotions and neutral expressions across Asian and Europeans, respectively. Group differences in neural activation beyond amygdala response occurred for the following regions covered with our protocol: European males showed stronger response of the lateral occipital gyrus bilaterally (left: -44, -80, -8, $k = 48$, $t = 3.69$, $p = .001$ uncorrected; right: 50, -78, -12, $k = 20$, $t = 4.03$, $p < .001$ uncorrected), the left cuneus (-14, -96, -6, $k = 21$, $t = 4.01$, $p < .001$ uncorrected), and the left fusiform gyrus (-8, -66, -8, $k = 121$, $t = 3.40$, $p = .001$ uncorrected) in the emotion vs. neutral contrast when directly compared with Asian males. For Asians, no stronger neural activation occurred compared with Europeans, and furthermore, no significant inter-Asian differences were observed at the applied threshold.

DISCUSSION

This study investigated the behavioral performance and neural activation during an explicit emotion recognition task to examine the impact of exposure and duration of exposure to emotional expressions of a new, different ethnic group in Asian immigrants. In concordance with previous studies and according to our *a priori* hypothesis, bilateral amygdala activation in both samples for all emotions was observed, further supporting the role of the amygdala as a "relevance detector" (Sander, Grafman, & Zalla, 2003), which explains responsiveness to a broader spectrum of biologically relevant stimuli. Therefore, the amygdala seems to be fundamental in emotion processing as a part of the underlying neural network, which seems to be less influenced by socialization and cultural background.

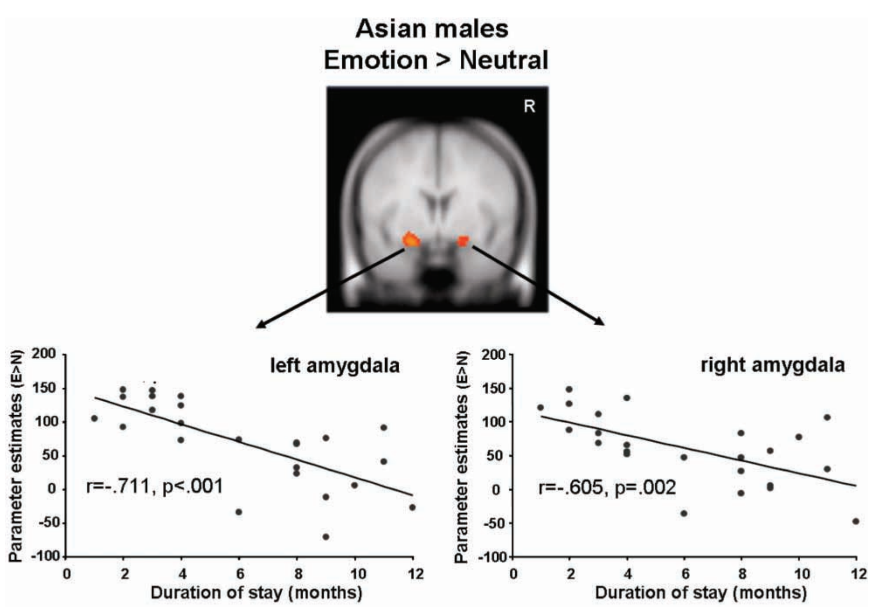

Figure 4. Correlation analysis between mean parameter estimates of the amygdala region and duration of stay in Europe (months), showing a significant negative association (left: $r = -.711$, $p < .001$; right: $r = -.605$, $p = .002$), indicating stronger amygdala response in those Asian participants with shorter duration of stay and thus probably reflecting adaptation effects on the neural level.

The alien-effect on amygdala activation

In general, the Asian sample demonstrated significantly stronger neural response of the amygdala when asked to explicitly recognize the emotions presented by Caucasian actors. No significant inter-Asian difference occurred. Hence, this finding of an alien-effect corroborates most published results on face processing investigating ethnic group effects (e.g., Hart et al., 2000; Lieberman et al., 2005). Regarding incidental emotion processing, Moriguchi et al. (2005) presented Caucasian and Japanese facial expressions of emotions according to the Ekman criteria and failed to elicit amygdala activation in the Japanese sample above the significance threshold. They observed significantly stronger amygdala response in Caucasian subjects to fearful faces (both Caucasian and Japanese stimuli) as compared to Japanese subjects. This implicitly assumes that Caucasians responded differently to the Western accent of expressions (Ekman criteria), thereby activating the emotional system while Japanese subjects had more difficulties and had to rely on a template matching system. Authors doubted the universality of these particular fear expressions in Japanese and Caucasian subjects, as all Japanese subjects rated the expressions as surprised. However, authors presented only happy and fearful faces during a passive viewing task. Hence, we believe that the sample characteristics (our sample consisted of male exchange students with a short residency time in Austria), divergence in task instruction, stimulus material, and gender of subjects, as well as methodological differences, led to the discrepant findings. Chiao et al. (2008) observed elevated amygdala response to in-group fear faces in Japanese Caucasian Americans, which is in part contrary to our findings. However, in our opinion, the results do not really conflict with our data as the setting of the Chiao et al. study was totally different and the authors did not investigate adaptation effects but were interested in cultural differences in the processing of in-group and out-group emotional faces. In our study, however, we did not directly compare in-group vs. out-group faces but were more interested in analyzing adaptation effects in Asian immigrants who have just moved to another culture. Thus, although both studies address important aspects of cultural impact on emotion processing, the aims were quite different.

Beyond the diverging setting, study focus and used emotions, in our study we directly compared emotional vs. neutral face processing, whereas in the study conducted by Chiao et al. (2008) no control condition is mentioned. Moreover, Chiao et al. report data from 10 Caucasian subjects and 8 Japanese subjects, mixing females and males. Our sample consists of 24 Asian male immigrants and 24 Caucasian males, applying an optimized protocol to measure reliable amygdala activation.

We observed a significant inverse correlation between duration of stay and amygdala activation during emotion processing, indicating adaptation and familiarity effects on the neural level and thus underlining the neural basis of the ‘‘alien-effect’’. Interestingly, duration of residency showed no impact on behavioral performance. In light of the significant correlation of amygdala activation and duration of stay, the lack of a significant association of behavioral performance with residency time may indicate that the underlying neural activation shows earlier adaptation effects than the behavioral performance. In the study by Elfenbein and Ambady (2002) statistically significant improvement in performance was detectable after 2.4 years spent in the foreign culture. However, the neural correlates of these participants were not investigated. Hence, the lack of a significant association of behavioral performance and duration of stay might be due to the restricted time of residency (maximum 1 year) in our inclusion criteria since this was a cross-sectional study. We believe that the association between duration of stay and amygdala activation reflects neural learning and acclimatization processes that can be measured within the first year and eventually might also improve recognition accuracy. Future longitudinal studies with several time points would be necessary to clarify after what time adaptation effects can be measured in which neural regions and when these neural changes lead to detectable improvements in performance. These studies would be necessary to gather more knowledge on the individual adaptation process and its impact on emotion recognition performance as well as on the underlying neural network, in particular amygdala activation. Moreover, investigating adaptation effects in separate nuclei of the amygdala over time might highlight the different functions of these cell-clusters that strongly interact. In particular, the basolateral nucleus is known to be important for learning (e.g., Laurent, Marchand, & Westbrook, 2008) and the central nucleus is essential for adaptation to chronic stress (e.g., Keen-Rhinehart et al., 2008) and, as shown in animal studies, might be relevant for a wide range of attentional processes, including both those involved in the acquisition of new learning and those involved in directing action (Holland, Han, & Gallagher, 2000).

For European subjects a significant correlation between recognition accuracy and amygdala response emerged, further supporting previous findings from our laboratory, where an association between explicit emotion recognition performance and amygdala activation in European females and males was also observed (Habel et al., 2007). No such association was found in Asians, suggesting that novelty aspects (Caucasian faces depicting Western expressions of emotions) might be stronger when confronted with foreign expressions of emotions, exerting higher activation in emotion sensitive and relevance detecting areas such as the amygdale: probably reflecting one neural substrate of the ‘‘alien-effect’’. Moreover, this stronger amygdala activation might also be related to motivation and emotional learning (e.g., Hooker, Germine, Knight, & D’Esposito, 2006), as Asian immigrants may want to assimilate with the host culture and thus emotional expressions of the foreign ethnic group exhibit a strong salient cue, as has also been shown previously (Elfenbein & Ambady, 2002).

Due to the fact that our Asian subjects have only been in Europe for a short time (mean: 6.1 months), emotion discrimination of Caucasian expressions may pose a greater challenge for them, as Western faces might show higher ambiguity and intensity in their expressions than familiar Asian faces (see also Elfenbein, Beaupré, Lévesque, & Hess, 2007).

Emotion recognition performance

The ‘‘alien-effect’’ was also evident in the emotion recognition performance, as recognition accuracy differed significantly between groups: Asian subjects had greater difficulties with Caucasian expressions of disgust and anger, which was apparent in their behavioral performance during scanning.

Disgust is ranked among the Western concept of basic emotions (cf. Ekman, 1984) and is also, for instance, listed as a primary emotion in an old Sanskrit text (*Rasadhyaya*, cf. Shweder, 1993). Still, cross-cultural studies frequently report significant differences for this emotion between Asian and American samples (Huang, Tang, Helmeste, Shioiri, & Someya, 2001; Shioiri, Someya, Helmeste, & Tang, 1999a, 1999b). Elfenbein and colleagues (2007) also observed significant differences in disgust recognition between American and African subjects, and authors speculate about the influence of intensity of expression. While strong expressions of disgust might be sanctioned in Western cultures, Eastern raters might find them especially difficult, in particular in light of the fact that Asians generally show less intense negative emotions. This is supported by our data at least for recognition of disgust, as the two stimuli with highest confusion rates are the most intense expressions of all disgust stimuli presented. Despite intensity, the expression style might also exert a major influence on performance: Rozin, Lowery, and Ebert (1994) differentiate between the ‘‘core disgust’’ characterized by nose wrinkle and the combination of gape and tongue extension, whereas an upper lip retraction rather functions as a sign for ‘‘extended disgust’’, and the authors suggested that this expression style might be more prone to cultural influences. Our evoked expressions of disgust clearly differed in the facial expression, with half of the stimuli showing upper lip retraction (three out of six stimuli) and the other half characterized by gape and tongue, probably also influencing the results. Future neuroimaging studies with more stimuli per category might highlight differences in expression processing.

Recently, Yuki, Maddux and Masuda (2007) demonstrated that Japanese students are more likely to infer the emotion from the eye region, rating happy eyes-faces as happier and sad eyes-faces as sadder. By contrast, when American students were judging emotions, cues displayed in the mouth region were weighted more strongly. The complexity of disgust plus the differences in expression, the novelty of Caucasian faces, and the related culturally driven evaluation may constitute the origin of this reduced accuracy and increased neural activation, thereby serving as a possible explanation of the ‘‘alien-effect’’.

Other regions involved

Besides amygdala, other relevant structures of the brain have been documented to be involved in the network underlying disgust recognition and might be associated with these behavioural differences:

Insula and basal ganglia activation have frequently been associated with processing of disgust (Phillips et al., 1997; Sprengelmeyer, Rausch, Eysel, & Przuntek, 1998). Moreover, significant differences in insula activation have been observed for Caucasian and Japanese subjects during face processing (Moriguchi et al., 2005), suggesting that an out-group effect is also apparent in other structures beyond amygdala. Future studies with whole brain coverage might elucidate involvement of insula and basal ganglia activation in the neural network underlying the ''alien-effect'' and whether duration of stay also exerts a significant influence on the neural activation of these regions.

European males showed significantly stronger activation in occipital regions which are mostly linked with face processing and object recognition, probably indicating expert knowledge (e.g., fusiform face area), and attentional processes enabling classification and distinguishing between emotions (e.g., cuneus), prompting higher recognition accuracy (see Haxby, Hofmann & Gobbini, 2002 for review).

Laterality effects

As we observed activation of left and right amygdala without any laterality effect, our data supports results of meta-analyses of neuroimaging studies demonstrating no consistent lateralization effect (Costafreda, Brammer, Davis, & Fu, 2008; Wager, Phan, Liberzon, & Taylor, 2003) and preceding results on bilateral activation during emotion processing (Habel et al., 2007; Winston et al., 2003; Yang et al., 2002). Furthermore, bilateral amygdala response during the perception and evaluation of biologically relevant sensory stimuli is supported by interaction analysis findings (Das et al., 2005). Functional correlations of the amygdala with other regions involved in emotion processing—mainly fusiform gyrus and inferior occipital gyrus—indicate significant connectivity with left and right amygdala (Das et al., 2005; Keightley et al., 2003). Consequently, we assume that lateralization effects might only occur with other task requirements, e.g. emotional memory (Kilpatrick & Cahill, 2003; Sergerie, Lepage, & Armony, 2006). However, the different functionalities of left and right amygdala for various tasks have to be further investigated.

Limitations

Since this was a cross-sectional study we cannot make any inferences on the further course of the adaptation process, in particular regarding emotion recognition performance. As pointed out above, we can only speculate that the initial difficulties apparent in the lower recognition accuracy may diminish after a certain time spent in the foreign culture and only longitudinal studies with several time points allow demonstration of neural and behavioral learning processes and the underlying transfer processes.

Moreover, the impact of several influencing factors such as personality traits that have been shown to influence emotional processes and amygdala activation (e.g., Canli, Sivers, Whitfield, Gotlib, & Gabrieli, 2002; Hooker, Verosky, Miyakawa, Knight, & D'Esposito, 2008) has not been investigated here.

We were particularly interested in cultural effects on amygdala activation and thus relied on a specifically optimized protocol with restricted coverage. However, in light of the significant behavioral differences for disgust and anger, whole brain coverage might be more favourable to detect differences in higher cortical areas (e.g., insula) and enable analysis of effective connectivity of the amygdala within the emotional network. In the future this should be possible using multiarray head coils with improved sensitivity.

Moreover, presenting more stimuli per emotion would have allowed emotion-specific analysis and thus might have enabled further understanding of recognition difficulties apparent in significantly reduced performance for angry and disgust expressions in Asian males.

Despite the lack of standardized and validated stimuli from Pakistani or Chinese subjects in our stimulus material, presentation of these stimuli would have enabled a thorough analysis of in-group and out-group effects. This should be implemented in future studies to gain more knowledge on emotion recognition processes and their interaction with adaptation effects. Moreover, further studies might want to investigate the impact of duration of stay on the neural substrates of the in-group and out-group effects in facial emotion recognition.

Due to the fact that we only investigated males, interaction of gender and duration of stay and its impact on emotion recognition and amygdala activation were not examined. However, investigation of emotional effects in female and male immigrants not only has important implications for the understanding of gender-specific emotional functioning, helping to further characterize gender differences in emotion processing (behavior: e.g., Hall & Matsumoto, 2004; fMRI: e.g., Wrase et al., 2003), but might also highlight gender differences in (neural) adaptation and acclimatization processes.

CONCLUSION

In this study we aimed at investigating the ''alien-effect'' as an initial problem during cultural assimilation and examined this effect on a behavioral and neural level. This study has revealed bilateral amygdala activation to emotional expressions in Asian and European subjects. In the Asian sample a stronger response of the amygdala bilaterally was observed and paralleled by reduced performance, especially for disgust and anger. Together with a significant inverse correlation between duration of stay and amygdala activation, this likely represents behavioral and neural correlates of the ''alien-effect''. We conclude that exposure to a foreign ethnic group is a relevant factor for neuroimaging studies addressing emotion processing. In times of globalization and increasing international exchange and interaction, understanding nonverbal communication styles, e.g., accents in emotional expressions, is critical for successful interaction between members of different ethnic groups and this competency underlies adaptation effects.

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