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Transcultural differences in brain activation patterns during theory of mind (ToM) task performance in Japanese and Caucasian participants

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Background: Theory of mind (ToM) functioning develops during certain phases of childhood. Factors such as language development and educational style seem to influence its development. Some studies that have focused on transcultural aspects of ToM development have found differences between Asian and Western cultures. To date, however, little is known about transcultural differences in neural activation patterns as they relate to ToM functioning.
Experimental methods: The aim of our study was to observe ToM functioning and differences in brain activation patterns, as assessed by functional magnetic resonance imaging (fMRI). This study included a sample of 18 healthy Japanese and 15 healthy Caucasian subjects living in Japan. We presented a ToM task depicting geometrical shapes moving in social patterns. We also administered questionnaires to examine empathy abilities and cultural background factors.
Results: Behavioral data showed no significant group differences in the subjects' post-scan descriptions of the movies. The imaging results displayed stronger activation in the medial prefrontal cortex (MPFC) in the Caucasian sample during the presentation of ToM videos. Furthermore, the task-associated activation of the MPFC was positively correlated with autistic and alexithymic features in the Japanese sample.
Discussion: In summary, our results showed evidence of culturally dependent sociobehavioral trait patterns, which suggests that they have an impact on brain activation patterns during information processing involving ToM.

Keywords: Transcultural; fMRI; Theory of mind; MPFC; Sociocultural background.

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Theory of mind (ToM) is the tendency to explain one's own and others' actions in terms of beliefs, desires, and goals (Castelli, Frith, Happé, & Frith, 2002). This aspect of social cognition is especially crucial for active engagement in a culture (Duffy, Toriyama, Itakura, & Kitayama, 2009, p. 358), because mentalizing abilities are necessary to react adequately to the environment in a socially accepted way (Bruene & Bruene-Cohrs, 2006). ToM abilities have been found to rely on individuals' cultural backgrounds. A cross-cultural study examining children and adults from North America and China showed that educational styles have an effect on the time course of ToM development (Wellman, Fang, Liu, Zhu, & Liu, 2006). Naito and Koyama (2006) found that Japanese children developed false-belief task skills later than Western culture children but had a tendency to interpret situations by using implicit social information. The authors hypothesized that Japanese children's tendency to infer social meanings might be due to early social behavior training, including expressing and understanding emotions and thoughts implicitly (see also Hendry, 1986). Furthermore, Tardif and Wellman (2000) observed different uses of ToM-related language in Chinese- and English-speaking children (Li & Rao, 2000). According to Naito and Koyama (2006), who investigated Japanese and Caucasian children, as well as Lee and colleagues (Lee, Olson, & Torrance, 1999), who observed Chinese children, this might be due to cultural-specific differences in language use, such as the use of the verb "to think (falsely)" in Asian cultures. In their study of adults, Matsuda and Nisbett (2001) found that the Japanese made more statements about contextual information and relationships while performing a picture-viewing task than Americans did. Thus, it seems that Asians pay more attention to the general emotional implication of a situation than to the details (Shweder et al., 1998). Taken together, these results indicate that the development and application of ToM abilities (i.e., the use of ToM-related language and application strategies) may be culturally dependent.

In imaging studies, the following specific brain networks have been suggested to be important for ToM abilities: the temporal and prefrontal cortical areas—(medial (MPFC) and dorsolateral prefrontal cortex (DLPFC)—and the amygdala (see Castelli, Happé, Frith, & Frith, 2000; Voellm et al., 2006). Because there are cultural differences in the mode and development of ToM, one might expect different ethnocultural groups to exhibit different brain activation patterns when performing ToM tasks. To date, however, only two studies have explicitly addressed cultural differences in ToM-related brain activation in adults. A functional magnetic resonance imaging (fMRI) study that compared American monolinguals and Japanese bilinguals proposed a differential effect of language education on ToM-related brain activation (Kobayashi, Glover, & Temple, 2006). While the ventromedial prefrontal cortex and precuneus were activated in both groups, the inferior frontal gyrus and the temporoparietal junction (TPJ) were activated in a culture-dependent manner during ToM task-performance. Additionally, a study comparing Japanese and American subjects using an Asian and an American version of the "eyes task" (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997) found activation in the superior temporal sulcus during same-versus other-culture mental state decoding in both groups but did not hint at a differential recruitment of brain areas (Adams et al., 2010).

In the present study, we investigated ToM abilities in a sample of native Japanese and a group of Caucasian individuals living in Japan. Activation patterns were examined by fMRI in implementing a sophisticated ToM task depicting moving geometrical shapes acting in social patterns (Abell, Happé, & Frith, 2000). This paradigm has been validated for the assessment of ToM abilities in autism spectrum disorders (Castelli et al., 2002), schizophrenia (Russell, Reynaud, Herba, Morris, & Corcoran, 2006), brain damage (Weed, McGregor, Feldbaek Nielsen, Roepstorff, & Frith, 2010), and alexithymia (Moriguchi et al., 2006). Using this paradigm, this study aimed to examine culturally dependent brain activation patterns associated with ToM abilities.

Our first aim was to assess behavioral performance on the task. We expected that the appropriateness of oral descriptions of the videos and the use of ToM-related language by Japanese participants would differ from that used by Caucasian participants. Because Japanese individuals reportedly evaluate information more contextually and less emotionally (Matsuda & Nisbett, 2001; Moriguchi et al., 2005), we expected the Western participants to express more ToM-related vocabulary and the Japanese participants to describe the videos more accurately in a social context. The differences between Caucasians and Japanese were expected to be more prominent for descriptions of movements that include social patterns than for goal-directed or random movements. Moreover, language differences concerning mentalizing terms might occur due to differences in styles of describing social interactions.

Our second aim was to analyze brain activation patterns by fMRI. Looking at differential activation patterns in two cultural groups would likely increase our knowledge about biological and neuropsychological factors related to mentalizing abilities, because cultural similarities and differences in basic brain functions or brain activations could exist. Consistent with previous findings related to general social cognition tasks (Chiao et al., 2009, 2010; Moriguchi et al., 2005; Zhu, Zhang, Fan, & Han, 2007), we expected the activation of the amygdala and the MPFC to be more distinct in Caucasian participants presented with a ToM task.

If brain activation differences between the study groups were found, our third aim was to analyze the correlations between the activation patterns and the participants' transcultural backgrounds to target reasons for ToM-performance differences and differential activation patterns. Thus, we administered questionnaires assessing the participants' level of acculturation. The questionnaires also assessed alexithymic traits, empathy abilities, and autistic traits, as these have been shown to correlate with reduced ToM abilities (Castelli et al., 2002; Moriguchi at al., 2006; Rogers, Dziobek, Hassenstab, Wolf, & Convit, 2007).

This is one of the first studies to observe transcultural differences in ToM performance by a sophisticated paradigm and a functional imaging approach. This study is the first to apply wide-ranging questionnaires to examine the possible impact of sociobehavioral traits on ToM functioning.

EXPERIMENTAL METHODS

Participants

The sample consisted of 18 healthy Japanese (mean age = 34.8, *SD* = 9.8; 9 women; 9 men) and 15 healthy Caucasian (mean age = 30.9, *SD* = 8.1; 8 women; 7 men) participants. Movement-provoked mental state attribution was examined by implementing a ToM paradigm using moving geometrical shapes. All Japanese participants were native speakers and were recruited personally. The Caucasian participants were recruited via advertisements at the international centers of Kyoto language institutes and Kyoto University. All of the Caucasian participants were native speakers of German and English or had excellent English abilities (nationalities: 5 German, 4 American/Canadian, 1 French, 2 Dutch, 1 Russian, 1 Danish, 1 Polish), and their mean duration of stay in Japan was 28.1 months (*SD* = 20.6). None of the participants had a history of psychiatric disorders, according to the SCID I, and none were receiving psychotropic medication or had neurological disorder. All had normal vision and were right-handed. The study protocol was approved by the University of Kyoto ethics committee according to the Declaration of Helsinki (1975, revised 1984). Written, informed consent was obtained from all participants before they were enrolled in the study.

Stimuli and procedure

The "moving shapes" paradigm, first used by Abell and colleagues (2000), was presented to the participants. We presented nine of the 12 original silent, animated videos (see http://sites.google.com/site/utafrith/research for examples); each had a big, red triangle and a small, blue triangle moving in a framed, white screen. Because a behavioral study with a clinical study group (Koelkebeck et al., 2010) had found that three videos were less reliable for discriminating between patients and control subjects than the other videos, these videos were excluded. The remaining nine videos were provided in a shorter version (24 s each) without diminishing the original meaning. Three types of animations were displayed: (1) random movement sequences (RM), in which the triangles purposelessly moved around (e.g., bouncing off the walls); (2) goal-directed movement sequences (GD), in which one triangle acted and the other one reacted (e.g., fighting) with no indication of one reading the other's mind; and (3) ToM sequences, in which the triangles interacted as if they read each other's mind (e.g., seducing). Before the experiment, the participants were informed about the session procedure and the different conditions without explicitly being told the aims of the study.

The nine videos were presented in a blocked design. The participants saw the videos in 30-s blocks, consisting of 24 s of video presented in a pseudorandomized sequence, followed by a 6-s question period. The order of blocks was counterbalanced across participants, and there were three counterbalanced orders of presentation. The overall presentation time was 4.5 min. The participants were told that they would see videos and should pay attention to them. The experiment used the Presentation software package (by Neurobehavioral Systems Inc., Albany, CA, USA). Each participant's head position was stabilized with a vacuum head cushion. To ensure vigilance, the participants were asked whether they thought the triangles' movements were (1) related to each other, (2) random, or (3) expressing feelings and emotions; they responded by pressing a button after each video was presented. A forced-choice paradigm with three response categories (corresponding to the video types) was used.

The "moving shapes" videos were presented a second time, after the fMRI experiment, in a quiet room free of auditory and visual distractions. The computer monitor was placed directly in front of the participants. The participants were asked what they thought the triangles were doing. Their answers were recorded and later evaluated by the scoring criteria provided by Abell and colleagues (2000). The answers were evaluated by experienced raters according to three dimensions: intentionality (degree of mental state attribution, amount of ToM-related language use: 0–5 points), appropriateness of the answers (degree of correctness: 0–2 points), and length of answers (0–4 points).

Questionnaires and statistical analysis

We administered several questionnaires in a Japanese, German, or English version. An adapted version of the Suinn-Lew Asian Self-Identity Acculturation Scale (SL-Asia) (Suinn, Ahuna, & Khoo, 1992) was given to the participants. It measures the level of identification with one's own culture and a foreign culture. In this study, a score of 1 indicated high acculturation with Japanese culture, whereas a score of 5 indicated high acculturation to Western culture. We also administered the American Asian Multidimensional Acculturation Scale (AAMAS) (Chung, Kim, & Abreu, 2004) in English and in translated German and Japanese versions. The AAMAS measures acculturation level and consists of two scores: acculturation to one's own culture and acculturation to the foreign culture. The scale can be subdivided into several subscales, including food consumption habits, cultural knowledge, language knowledge, and identification with their own and the foreign culture. We also administered the Individualism/Collectivism Scale (IND/COL) by Triandis (1994). The foreign participants also completed a questionnaire about living circumstances, adapted from Tanaka (2000).

Participants were assessed with a validated English, German, or Japanese version of the Autism Spectrum Questionnaire (AQ) by Baron-Cohen (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001; Wakabayashi, Tojo, Baron-Cohen, & Wheelwright, 2004). The AQ assesses autistic traits in a normal population. Additionally, the 20-item version of the Toronto Alexithymia Scale (TAS) (Komaki et al., 2003; Taylor, Ryan, & Bagby, 1985) was administered to measure alexithymic traits, such as the ability to judge and describe one's own feelings. The Japanese version was used with the permission of Gen Komaki. We also administered the Interpersonal Reactivity Index (IRI) by Davis (Aketa, 1999; Davis, 1983; Paulus, 2006), which measures empathy abilities. Handedness was assessed with the Edinburgh Handedness Questionnaire (Oldfield, 1971). Socioeconomic status (SES) was assessed with the Hollingshead scale (Hollingshead, 1975).

Statistical analyses were performed with SPSS (SPSS 18.0 for Windows, SPSS, Inc., Chicago, IL, USA). Normal distribution was confirmed with the Kolmogorov-Smirnov test. For between-group comparisons, Student's *t*-test and chi-squared tests were applied as appropriate. Correlations were determined with the Pearson correlation coefficient. The significance level for all analyses was set at $p < .05$ (two-tailed).

Behavioral data were first analyzed via repeated-measures analyses of variance (ANOVA) for each rating type (intentionality, appropriateness, and length), with one between-subjects factor (group: Caucasian or Japanese participants) and one within-subjects factor (video type: ToM, GD, and RM sequences). Correlational analyses were also conducted. Furthermore, we used analyses of covariance (ANCOVA) to control for possible effects of neuropsychological functioning on ToM performance.

fMRI procedure and analysis

All participants received MRI scans with a 3-T scanner equipped with an 8-channel, phased-array head coil (Trio, Siemens, Erlangen, Germany). Functional images were obtained in a T2*-weighted gradient echo-planar imaging sequence, with the following sequence: TE = 30 ms; TR = 2500 ms; flip angle = 90°; FOV = 192 × 192 mm; matrix = 64 × 64; 40 interleaved axial slices of 3-mm thickness without gaps; resolution = 3-mm cubic voxels. The first two volumes were discarded for signal stabilization; the total number of volumes was 114. Functional imaging data were motion-corrected by a set of six rigid body transformations determined for each image. The images were spatially normalized to standard Montreal Neurological Institute (MNI) space and smoothed (Gaussian kernel, 6-mm, full-width at half maximum), using statistical parametric mapping (SPM8, Wellcome Department of Imaging Neuroscience, London, UK). A statistical analysis was performed by modeling the different types of video presentation conditions as variables within the context of the general linear model (convolved with a standard hemodynamic response function). The analyses in the present study focused on the contrast between ToM–RM video conditions, as suggested by Moriguchi and colleagues (2006). On the single-subject level, we extracted the contrast values for ToM-RM conditions. First, one-sample *t*-tests were performed on activation data for both groups separately. Random-effects analyses (*t*-tests for independent samples) were then performed to examine brain activation differences between the two groups. Age and gender were included as nuisance covariates.

Anatomical labels of reported coordinates (transformed from MNI to Talairach space, Mathworks, Natick, MA, USA; "mni2tal" MATLAB script available from http://eeg.sourceforge.net/) for peak voxel clusters were retrieved from the Talairach Daemon database (Lancaster et al., 2000) within a 5-mm cubical search range or from the SPM anatomy toolbox. The statistical significance level was set at $p < .001$, uncorrected.

RESULTS

Behavioral results

Demographic data, neuropsychology, and questionnaire results

There were no significant differences between the age, gender, or SES of the participants. None of the participants met pathology criteria for autism or alexithymia. The Japanese participants displayed higher TAS scores than the Caucasian participants; differences between groups were significant for the TAS total score and the second and third TAS subscales, indicating difficulties in describing emotions and a tendency of individuals to focus their attention externally. However, there was no significant difference between groups on the first subscale, which describes difficulties in identifying emotions. Furthermore, although the Japanese participants displayed higher scores on the AQ, this difference was not significant. There were significant differences on all AAMAS subscale scores except for "food consumption." According to the AAMAS, the Caucasian participants showed a lower identification with their own culture compared with the Japanese participants but were more knowledgeable when asked about a foreign culture. On the IND/COL, the Caucasian participants displayed higher levels of individualism, and the Japanese participants showed higher levels of collectivism, but these differences were not significant. No significant differences on any of the subscales of the IRI were observed. Acculturation levels for the two groups, as measured by the SL Asia, were comparable: Japanese: 1.9 (0.1), Caucasians: 3.9 (0.3) (for results of questionnaires, see Table 1).

Rating of videos

To analyze the rating results, we conducted three (video type) × 2 (group) ANOVAs. In the first ANOVA, rating type intentionality was the dependent variable. In this analysis, the main effect of video type, $F(1, 30) = 291.52$, $p < .001$, was significant. The main effect of group, $F(1, 30) = .64$, $p = .43$, and the interaction between group and video type, $F(1, 30) = 1.16$, $p = .29$, were not significant, indicating no response differences regarding the three conditions between the two groups. Planned post-hoc t-tests showed significantly reduced use of ToM vocabulary (intentionality) when describing the GD sequences, $t(30) = –2.028$, $p < .05$, in Caucasian participants compared with the Japanese participants. For the ToM and RM sequences, the differences failed to reach significance.

In the second ANOVA, the appropriateness of the answers was the dependent variable. In this analysis, neither the main effect of video type, $F(1, 30) = .21$, $p = .65$, or group, $F(1, 30) = .21$, $p = .89$; nor the interaction between group and video type, $F(1, 30) = 1.96$, $p = .17$, was significant.

The third ANOVA used rating type length as the dependent variable. In this analysis, the main effects for video type, $F(1, 30) = 63.19$, $p < .001$, and group, $F(1, 30) = 9.80$, $p = .004$, were significant, but the interaction between group and video type, $F(1, 30) = 3.66$, $p = .07$, was not. Planned post-hoc t-tests showed significantly reduced length when describing the ToM, $t(30) = –4.261$, $p < .001$, and GD sequences, $t(30) = –3.151$, $p < .005$, in Japanese participants compared with Caucasians. For the RM sequences, no difference was found.

fMRI

Within-group activations in response to ToM videos

For the ToM-RM contrast for Caucasian participants, differences were significant in the MPFC bilaterally—Brodmann's area (BA) 9, the left middle temporal gyrus (BA 21), the right temporal lobe (BA 40), the left parahippocampal gyrus (BA 36), and the right thalamus (see Table 1 and Figure 1)—at a statistical threshold of $p < .001$, uncorrected. No significant differences were found for Caucasian participants on the RM-ToM contrast. For the Japanese participants, no significant differences were observed for either the ToM-RM contrast or the RM-ToM contrast (see Table 2).

Between-group differences in response to ToM videos

A group comparison at a statistical threshold of $p < .001$, uncorrected, revealed significantly greater activation in the Caucasian participants compared with the Japanese participants in the MPFC (BA 8). At a threshold of $p < .005$, uncorrected, the Caucasians

TABLE 1
Characteristics and results of the study groups' questionnaires

	Japanese participants (n = 18)	*Caucasian participants (n = 15)*	*Statistics*
Age	34.8 (9.8)	30.9 (8.1)	$t(df = 31) = 1.21, p = 0.24$
Gender	♀9, ♂9	♀8, ♂7	$\chi^2(1) = 0.030, p = .86$
SES	49.3 (13.3)	45.7 (6.5)	$t(\text{df} = 30) = 0.96, p = 0.34$
TAS total subscale	45.4 (8.8)	38.3 (9.6)	$t(\text{df} = 31) = 2.58, p = .015$
(1) Difficulties in identifying emotions	12.1 (4.3)	10.8 (4.1)	$t(\text{df} = 31) = 0.95, p = .35$
(2) Difficulties in describing emotions	12.8 (4.3)	8.6 (2.7)	$t(\text{df} = 31) = 3.57, p = .001$
(3) Externally oriented thinking	20.5 (2.9)	18.9 (4.4)	$t(\text{df} = 31) = 2.11, p = .047$
AQ	15.3 (6.4)	12.8 (5.8)	$t(\text{df} = 30) = 1.24, p = .23$
AAMAS	73.4 (7.0)	58.4 (9.9)	$t(df = 31) = 4.50, p < .001$
Identification of own culture ~ foreign culture	41.2 (8.2)	73.5 (7.2)	$t(df = 31) = -12.04, p < .001$
	10.56 (2.71)	22.87 (1.25)	$t(df = 31) = -16.22, p < .001$
Language	16.0 (3.45)	27.89 (4.45)	$t\ (df = 31) = -8.63, p < .001$
Cultural identity			
	6.72 (2.6)	12.93 (1.8)	$t(df = 31) = -7.81$, p < .001
Cultural knowledge			
	8.11 (2.11)	9.80 (2.65)	$t(df = 31) = -2.04, p < .050$
Food consumption			
IND/COL			
Collectivism	101.6 (29.0)	99.7 (11.5)	$t(df = 30) = -0.05, p = .96$
Individualism	83.3 (25.1)	92.1 (13.2)	$t(df = 31) = -1.46, p = .16$
IRI subscale			
(1) Fantasy	11.7 (3.8)	17.3 (16.5)	$t(df = 29) = -1.33, p = .22$
(2) Perspective taking	12.5 (2.1)	12.9 (7.2)	$t(df = 29) = -0.23, p = .83$
(3) Empathic concern	9.1 (2.3)	12.5 (9.3)	$t(df = 29) = -1.36, p = .19$
(4) Personal distress	12.7 (4.3)	21.7 (24.9)	$t(df = 29) = -1.38, p = .19$

Notes: AAMAS: Asian-American Multidimensional Acculturation Scale; AQ: Autism Spectrum Quotient; IND/COL:; Individualism/Collectivism Scale; IRI: Interpersonal Reactivity Index; SES: Socioeconomic Status; Suinn-Lew Asian Self-Identity Acculturation Scale; TAS: Toronto Alexithymia Scale.

displayed areas of greater activation on the ToM-RM contrast in the right superior frontal gyrus (BA 7), the right claustrum and the right parahippocampal gyrus (BA 35). The Japanese participants did not show any greater brain activation for this contrast at a threshold of p $<$ .001 or at a threshold of $p < .005$, uncorrected (see Table 3). In Figure 2, activation differences at a threshold of $p < .005$ are shown, so that the distribution of group differences is more evident.

Correlational analyses

For the correlational analyses, we extracted the averaged eigenvariates to obtain the fMRI signal intensity time series from the largest cluster of significant ToM-RM contrast group differences at a statistical threshold of $p < .005$, uncorrected, for both groups (MPFC; coordinates: 12; 48; 34). We then performed a partial correlational analysis in SPSS between the MPFC signal intensity time series and the questionnaire results, using gender and age as covariates. MPFC activation was found to be correlated with the first subscale (difficulties in identifying emotions) of the TAS ($r = .57$, $p = .027$) (see Figure 3A) and with scores from the AQ ($r = .52$, $p = .048$) (see Figure 3B) in the Japanese participants. For the Caucasian participants, no significant correlations were demonstrated between MPFC activation and the questionnaire scores.

DISCUSSION

The aim of our study was to observe intercultural differences in ToM in two groups of participants from different cultural/ethnic backgrounds. Therefore, we assessed behavioral and functional imaging data in a

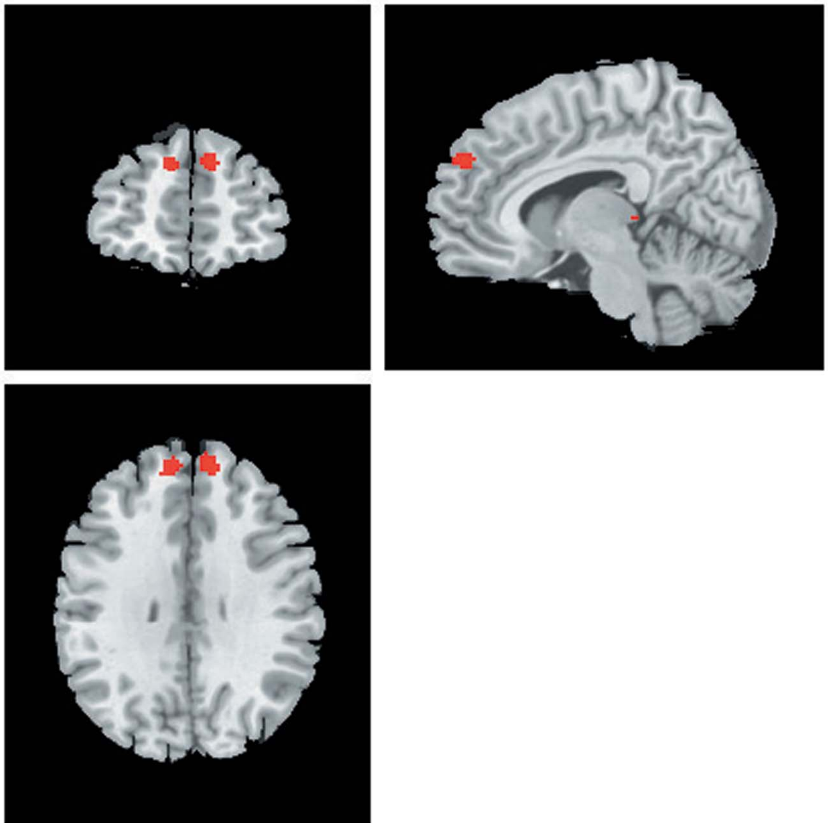

Figure 1. fMRI images showing activation for Caucasian participants during the presentation of ToM versus RM sequences ($p < .001$, uncorrected).

sample of Caucasian and Japanese participants, using a sophisticated ToM paradigm, and correlated these findings with data from transcultural and social-behavioral questionnaires.

We did not find any significant behavioral differences in the use of ToM-related vocabulary or the appropriateness of descriptions in the groups studied. A lack of significant behavioral ToM findings is consistent with previous data that show differences in ToM abilities at a younger age but similar levels across cultures in adulthood (for an account of ToM development, see Wellman, Cross, & Watson, 2001). These results indicate that, on the behavioral level, the paradigm we used might be relatively independent of transcultural performance differences. As the movies used as stimuli were silent, confounding variables such as language comprehension were reduced during task presentation.

On the other hand, fMRI results indicated a cultural background effect on brain activation. We found a higher level of MPFC activation in Caucasian participants compared with Japanese controls as well as higher activation of temporal parts of the brain on the ToM-RM contrast. In a previous ToM imaging study, Kobayashi and colleagues (2006) found a culturally dependent activation in the frontal parts of the brain among American monolinguals and Japanese bilinguals completing a second-order false-belief task.

We believe the above-mentioned group comparisons indicate that Japanese participants activate the MPFC to a lesser extent because they have been taught from early childhood to “read the air” (*kuuki wo yomu*), or to be attuned to unspoken social signals all around and to react in a socially accepted way. Naito and Koyama (2006) argued that Japanese individuals have a delay in ToM development compared with Western children but that they are able to understand social implications without explicit information. Thus, even though Japanese children seem to develop ToM abilities later than Western children, their performance might be more sophisticated, and they may mentalize with a lower level of ToM network activation.

This interpretation is partially consistent with a previous study by Chiao and colleagues (2009), who showed that during a self-estimation task, Westerners activated the MPFC more than Asian controls. They associated this finding with individualistic traits. However, they interpreted that individualistic Caucasians overactivate the MPFC because they constantly need to distinguish between themselves, others,

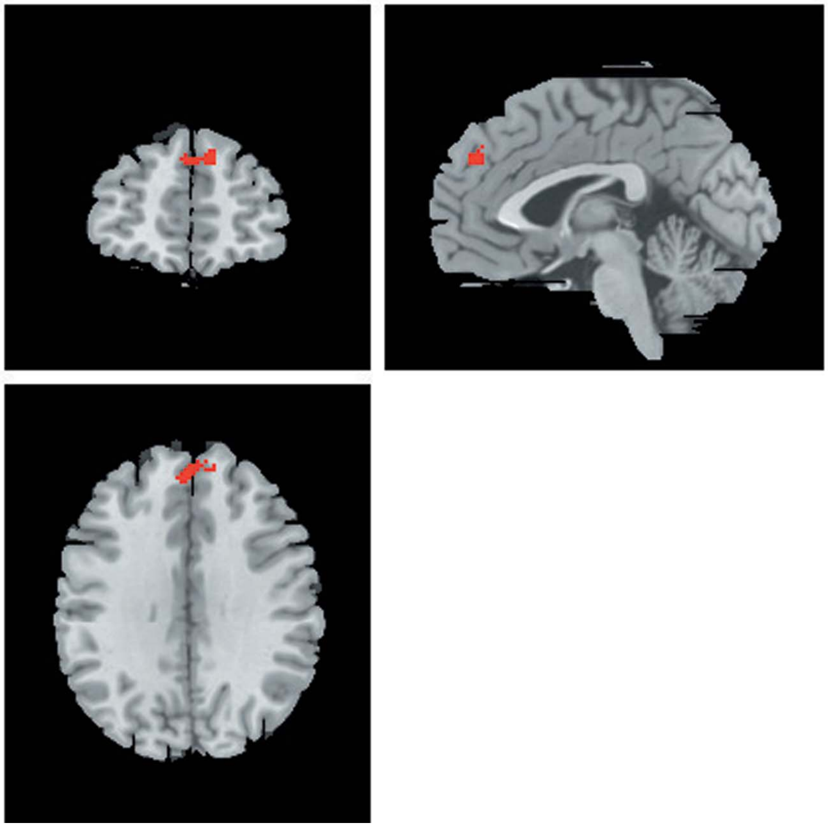

Figure 2. fMRI images comparing activation in Caucasian and Japanese participants during ToM video presentation in fMRI ($p < .005$, uncorrected).

and their surroundings, citing findings by Kitayama and colleagues (Kitayama, Duffy, Kawamura, & Larsen, 2003). They found that even when judging external objects, North Americans tend to relate this information to themselves, while Asians attend more to the social context. We could not simply reduce our findings to cultural differences because we could not find any significant between-group differences on the IND/COL. Therefore, this discrepancy should be addressed in further studies.

Our imaging results are consistent with previous studies; however, our investigation is one of the first not only to show transcultural differences but also to reveal the impact of transcultural sociobehavioral traits on brain activation during the presentation of a ToM task. We could not find any association between acculturation level (e.g., language abilities and cultural knowledge) or empathy, as assessed through the IRI; however, we did find differences between the TAS subscale score “difficulties in identifying feelings” and the AQ score and MPFC activation pattern in the Japanese participants. These results suggest that, within the Japanese group, those with more prominent alexithymic or autistic traits have to activate the ToM network more due to difficulty in describing emotions and feelings and their externally oriented thinking style. Thus, our attempt to explain the correlation between MPFC activation and AQ and a TAS subscore assumes that the stronger MPFC activation plays a compensatory role. This idea parallels one proposed by Marjoram and colleagues (Marjoram et al., 2006), who performed a functional imaging study on a sample of relatives of schizophrenia patients at high risk of psychosis.

Finally, a study on Chinese parental style showed that impulse control is especially valued in Asian countries (Chen et al., 1998). A similar manner of educational style might thus have an effect on the reaction to emotional stimuli (Moriguchi et al., 2005) and could result in a weaker activation of the MPFC. An alternative hypothesis that we cannot exclude might be that the Japanese participants did not perceive RM sequences as genuinely random and tried to find goals and intentions in the triangles’ behavior. This might account for the lack of differences in the contrast of ToM and RM sequences.

Taking all this together, we hypothesize that, due to their cultural background and education, Japanese individuals need to activate specialized brain areas less intensively than Caucasians. This might be due

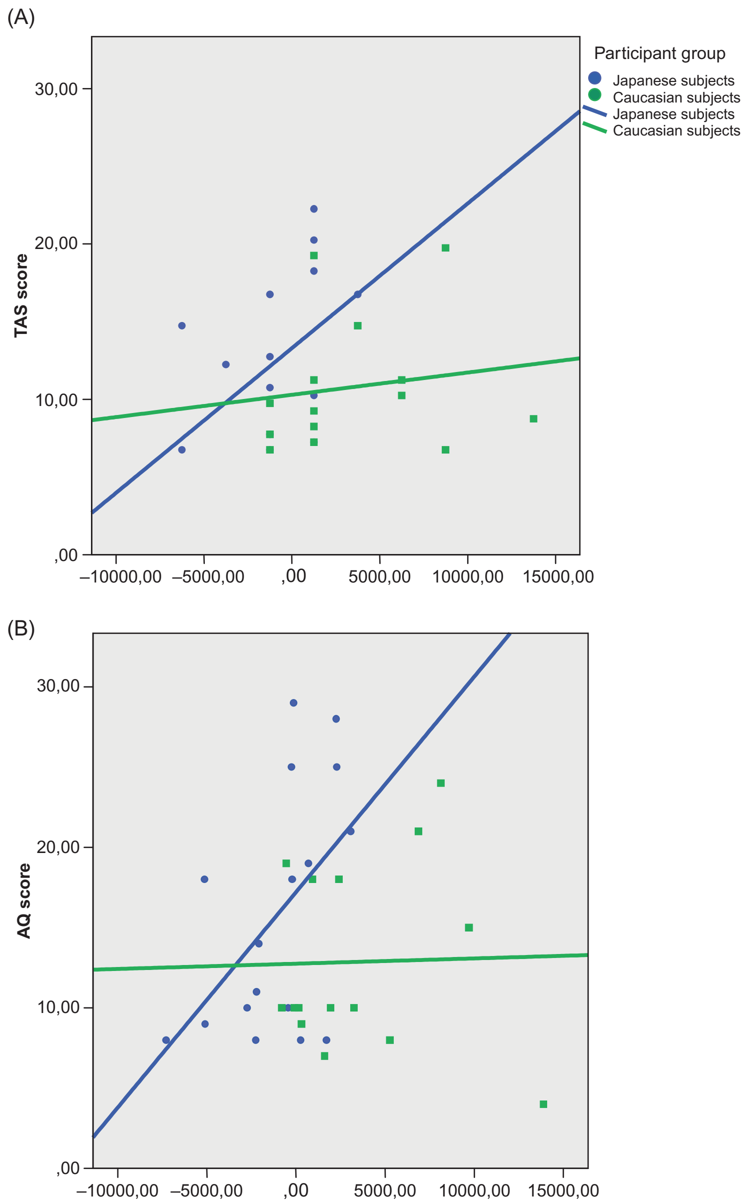

Figure 3. Correlations between the eigenvariates of MPFC activation of ToM-RM and the TAS subscale 1 (A) and the AQ score (B) in Caucasian and Japanese participants.

to better mentalizing abilities or a different manner of utilizing the brain areas that participate in the ToM network. Caucasians are thought to constantly monitor themselves and their surroundings; thus, their ToM network is activated more frequently. However, when Japanese participants display autistic or alexithymic sociobehavioral traits, their activation pattern equals that of Caucasian participants, probably due to compensation for reduced mentalizing abilities.

There are some limitations to our study. First, we do not have neuropsychological data for both study groups. Consequently, intelligence as a confounder cannot be ruled out; however, because the socioeconomic data of both groups did not differ significantly, we assumed that there were no substantial differences in intelligence levels. Second, the sample size in this study was small, and our Caucasian sample was quite heterogeneous regarding linguistic background and nationality. Group comparison may have been compromised by in-group differences among Caucasians. Few studies have focused on European–European or European–American comparisons in ToM. Lillard occupied herself with the question of a “European-American ToM” (1998). She

TABLE 2
Activations in response to videos in Japanese ($n = 18$) and Caucasian participants ($n = 15$)[a]

Talairach and Tournoux coordinates							
Group, contrast and brain region	*Brodmann's area*	*Hemisphere*	*x*	*y*	*z*	*Number of activated voxels*	z^b
Caucasian participants							
Theory of Mind vs. random movement							
Superior frontal gyrus (MPFC)	9	Right	12	52	30	70	3.66
Middle temporal gyrus	21	Left	−58	−12	−12	78	3.58
Superior frontal gyrus (MPFC)	9	Left	−8	50	30	52	3.54
Temporal lobe	40	Right	62	−54	22	59	3.44
Parahippocampal gyrus	36	Left	−22	−30	−20	9	3.36
Thalamus		Right	12	−30	8	10	3.36
Thalamus		Right	20	−28	10	8	3.28
Random movement vs. Theory of mind sequences							
–	–	–	–	–	–	–	–
Japanese participants							
Theory of mind vs. random movement sequences							
–	–	–	–	–	–	–	–
Random movement vs. Theory of mind sequences							
–	–	–	–	–	–	–	–

Notes: [a]In one-sample *t*-tests, $p < .001$, uncorrected, for all results.
[b]Expressed as the maximum within each area; local maxima are separated by a minimum of 8 mm.

TABLE 3
Differences in the ToM-RM contrast in Japanese ($n = 18$) and Caucasian participants ($n = 15$)[a]

Talairach and Tournoux coordinates							
Group, contrast and brain region	*Brodmann's area*	*Hemisphere*	*x*	*y*	*z*	*Number of activated voxels*	z^b
Caucasian > Japanese participants							
Superior frontal gyrus (MPFC)	8	Right	4	40	54	52	3.09
Superior frontal gyrus (MPFC)	9	Right	12	48	34	92	3.07
Claustrum		Right	30	−4	18	27	3.20
Parahippocampal gyrus	28	Right	22	−24	−12	22	2.89
Temporal lobe	37	Right	44	−46	−10	26	2.87
Japanese > Caucasian participants							
–	–	–	–	–	–	–	–

Notes: [a]$p < .005$, uncorrected, for all results.
[b]Expressed as the maximum within each area; local maxima are separated by a minimum of 8 mm.

referred to middle- and upper-class Americans with European origins, but assumed that many elements of their ToM are shared with Europeans as well. On the other hand, Lecce and Hughes (2010) recently found that British children outperformed Italian children on ToM tasks. It must be assumed that there is at least a small intragroup difference in our Caucasian sample, adding to interindividual differences. As a whole, we think the differences between Caucasian and Japanese participants far outweigh those; however, this needs to be proven with larger sample sizes.

Furthermore, we have to consider an effect of test location, as all tests were conducted in Japan. We also have to assume a selection bias on our results, as the participants all chose to live in Japan and might thus display specific personality traits. On average, the subjects stayed in Japan for approximately 28 months, and some acculturation effects have to be considered.

However, those are not likely to outweigh the effects of an individual's acculturation to his or her culture of origin. This issue should be addressed in future studies.

Finally, during the scan, the subjects were asked to assign each video sequence to a category to ensure their attention. This kind of instruction might have constituted a cue that may have influenced activation results.

Especially concerning imaging studies with clinical samples, our results suggest that attention should be paid to the participants' cultural backgrounds. Differences in the activation patterns of clinical samples are only relevant to those investigated in healthy populations of the same culture and may not apply when individuals of different cultures are compared.

In summary, we found a culturally dependent manner of activation in Japanese and Caucasian participants that seemed to be independent of factors such as acculturation or IND/COL but relied on personality traits such as autistic or alexithymic features. Research using a larger number of subjects is needed to further investigate specific cultural, socioeconomic, and personality aspects in different cultures.

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