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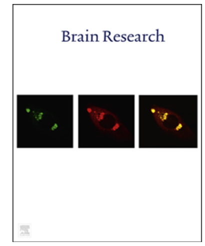

Research Report

The gender you are and the gender you like: Sexual preference and empathic neural responses

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ABSTRACT

Background: Empathy relates to the ability to share the emotions and understand the intentions and emotions of the other. Although it has been suggested that women have superior empathic abilities as compared to men, it is unknown whether it is the gender or the sexual preference of the individual that affects empathy. Given that sexual attraction has been reported to affect social behavior, the present study explored the possibility that sexual orientation affects behavioral measures of empathy as well as empathy related activations.
Methods: Fifty two heterosexual and homosexual women and men were scanned while performing an emotional judgment task involving emotional understanding of a protagonist.
Results: The behavioral and neuroimaging results indicate that empathy is related to the gender as well as the sexual preference of the participant. Individuals sexually attracted to men (heterosexual women and homosexual men) showed greater empathy than subjects attracted to women (heterosexual men and homosexual women). Furthermore, brain imaging data reveal that regions within the temporo-parietal junction (TPJ), showed sensitivity to the sexual orientation of the individual, such that it was activated more in subjects attracted to men than in subjects attracted to women while evaluating the emotional state of the other. Moreover, the activation in the TPJ was found to be correlated with the degree to which subjects were empathizing.
Conclusions: These results suggest that individual differences in empathy are related to the gender as well as the sexual orientation of the subject.

1. Introduction

Social cognition links together a vast array of abilities that help us function appropriately in interpersonal relationships in our everyday lives. Proper function in social circumstances depends, to a great measure, on our successful understanding of the people around us. Empathy is a central mechanism of understanding the other, which helps us sense the other's

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feelings and emotions (Rogers, 1957). Empathy is a multidimensional construct and comprises the cognitive as well as the emotional reactions of individuals to events experienced by other individuals. Thus, empathy may involve reactions such as emotion recognition, perspective taking and emotional contagion which may occur simultaneously or separately (Shamay-Tsoory, 2011).

Empathy and its various constructs have been shown to be sensitive to individual differences, particularly to gender related differences (Schulte-Ruther et al., 2008; Yang et al., 2009; Derntl et al., 2010; Pavlova et al., 2010). Indeed, several studies have supported the view of female superiority in empathy-related tasks, such as decoding non-verbal communication, picking up subtle nuances from tone of voice or facial expression, and judging a person's character (Klein and Hodges, 2001; Hall and Matsumoto, 2004). Although several studies failed to find gender differences in empathy (Bandstra et al., 2011; Roth-Hanania et al., 2011) it has been reported that women score higher than men on self-report measures of empathy (Davis, 1994; Baron-Cohen and Wheelwright, 2004). The findings regarding sex differences in empathy are in accordance with the fact that various psychiatric disorders, such as autism spectrum disease, conduct disorder, and antisocial personality disorder, which are often characterized by impaired empathy, are far more common among men (Chakrabarti and Baron-Cohen, 2006).

Recent meta-analyses have shown that empathy related activations include a series of different brain regions including the anterior cingulate, supplementary motor area and bilateral anterior insula (Fan et al., 2011; Lamm et al., 2011). On the other hand more cognitive aspects of empathy, including metalizing related tasks have repeatedly shown to activate the medial prefrontal cortex (MPFC), the temporo-parietal junction (TPJ), and the superior temporal sulcus (STS) (Frith and Frith, 2003; Vogeley and Fink, 2003; Decety and Lamm, 2007; Schulte-Ruther et al., 2008; Van Overwalle, 2009). Specifically, the TPJ is thought to be important in various social behaviors. The TPJ has a critical role in empathic processing (Cheon et al., 2011) and seems to be engaged in self-reference thoughts (Johnson et al., 2002), mentalizing about the other (Lombardo et al., 2010) as well as in emotion evaluation (Zysset et al., 2002; Winston et al., 2003), and has been shown to respond atypically in autism during mentalizing (Saxe and Wexler, 2005; Lombardo et al., 2011). A common denominator underlying these behaviors may be the integration and comparisons between self and other mental state. Thus, it might be speculated that the TPJ is a key region where the decoupling of self versus other representations occurs. While the TPJ seems to be responsible for self–other decoding, the MPFC appears to be involved in more abstract inferences about self and others. It has been shown that this region is recruited in self-knowledge, person perception, and mentalizing processes, all of which underlie empathy (Decety and Chaminade, 2003; Gallagher and Frith, 2003).

To date, few behavioral and neuroimaging studies (Canli et al., 2002; Bandstra et al., 2011; Lamm et al., 2011; Mercadillo et al., 2011; Roth-Hanania et al., 2011; Chun et al., 2012; Decety and Svetlova, 2012) have investigated gender differences in empathy. While several studies did not find any gender differences (Geangu et al., 2010; Bandstra et al., 2011; Roth-Hanania et al., 2011), some functional imaging studies have found evidence for sex related differences in empathy (Schulte-Ruther et al., 2008; Derntl et al., 2010; Chou et al., 2011). For example, Singer et al. (2006) showed that empathy-related activations are differently modulated in men and women by learned preferences, which are gained through social interactions. In line with this finding, it has also been found that women tend to recruit areas containing mirror neurons, such as the inferior frontal region, more prominently than men (Schulte-Ruther et al., 2008). Hence the question whether gender influences empathy skills is an open one which needs more exploration.

However, no study to date has examined sexual preference of the subject relates to different empathic abilities. Although sexual preference has been shown to be critical to social behavior (Liu et al., 2011), little is known about the relationship between sexual orientation and empathy and its underlying neural mechanism.

Sexual orientation is defined as the degree of sexual attraction to either men or women (Ellis and Ames, 1987). Studies on sexual preference have focused mainly on genes (Liu et al., 2011), prenatal hormones, and brain neuroanatomy (Bem, 1996; Rahman, 2005). It has been suggested that in homosexual men, the interstitial nucleus 3 of the human anterior hypothalamus is more female-like (Le Vay, 1991) and that in homosexual women, the grey matter in the perirhinal cortex, a region associated with social bonding, displays a more male-like structural pattern (Ponseti et al., 2007). Recently, Savic and Lindstrom (2008) demonstrated differences in brain asymmetry and connectivity related to sexual preference. They found that homosexual men showed similar amygdala connectivity patterns to heterosexual women (i.e., connections with the caudate, putamen, and prefrontal cortex), while the pattern of connectivity of homosexual women resembled that of heterosexual men (i.e., connection with the cingulate cortex).

In accordance with these anatomical findings, a considerable amount of personality and behavioral findings have demonstrated that homosexual men are more feminine than heterosexual men and that homosexual women are more masculine than heterosexual women (Haslam, 1997). Homosexual and heterosexual individuals are also found to differ on measures of masculine instrumentality and feminine expressiveness (Lippa, 2000). Furthermore, investigations of cognitive skills have shown that homosexual men demonstrate female-typical responses in cognitive-related tasks, such as spatial location memory, recall of spatial landmarks during navigation, and phonological and semantic fluency (Rahman, 2005), indicating similarities between the brains of heterosexual women and homosexual men.

Collectively, these findings support the possibility that individual differences in empathy may be related not only to gender, but also to sexual preference. If indeed women show higher levels of empathy and homosexual men show similar neural and behavioral patterns, then it is possible that individuals attracted to men (homosexual men, heterosexual women) would show higher levels of empathy than individuals attracted to women (homosexual women, heterosexual men). To the best of our knowledge, no brain imaging study has investigated sexual preference differences in social

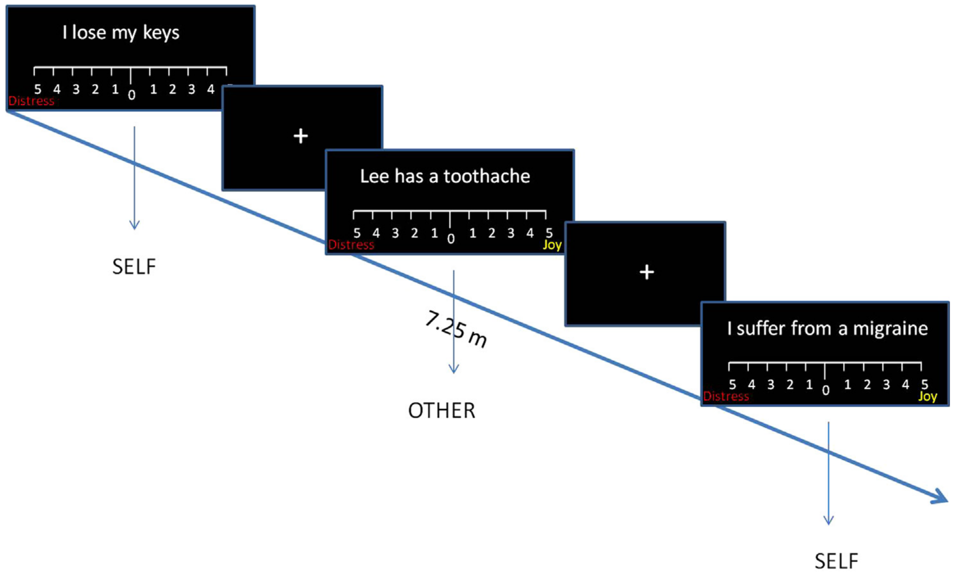

Fig. 1 – A schematic design of the fMRI task.

behavior and empathy. Therefore, the aim of the present study was to examine differences in the neural empathic responses of individuals attracted to men versus individuals attracted to women. Given that gender differences have been reported for the neural correlates of emotional perspective taking (Schulte-Ruther et al., 2008), in the current study we used an emotional mentalizing task in which subjects rated the emotional magnitude of events happening to another protagonist ("OTHER" condition) or to themselves ("SELF" condition, Fig. 1). It was speculated that individuals attracted to men would show higher behavioral and neural empathic responses toward the protagonist as compared to subjects attracted to women. Specifically, it was hypothesized that both the gender and the sexual orientation of the subjects would interact so that heterosexual women will show the highest empathy followed by homosexual men, homosexual women and heterosexual men. Finally, we predicted that the levels of sexual orientation tendencies, as assessed by the Klein Sexual Orientation Grid (KSOG) (Klein, 1993) would predict the levels of empathy in the task.

2. Results

2.1. Behavioral results

To examine the empathic abilities of the participants an empathy index was calculated as the ratio between the ratings for SELF and OTHER protagonists. For purposes of convenience, the index was multiplied by −1, indicating that higher index scores represent higher empathy and vice versa. The index was calculated for each subject.

A univariate ANOVA of the empathy index, with gender (women, men) and attraction (attracted to men, attracted to women) as the between-subject factors was performed. This analysis revealed a significant attraction effect ($F(1,48)=4.08$, $p=0.049$), indicating that individuals attracted to men (heterosexual women and homosexual men) scored higher on this index than individuals attracted to women (homosexual women, heterosexual men). Main effect for gender ($F(1,48)=3.97$, $p=0.05$) indicated higher empathy scores for men over women, and an interaction was found between gender and attraction ($F(1,48)=4.15$, $p=0.047$). A follow-up one-way ANOVA for sexual orientation (homosexual men, heterosexual men, homosexual women, heterosexual women) was carried out to further explore differences in empathy levels among homosexual and heterosexual women and men. This analysis indicated a significant sexual orientation effect ($F(3,48)=3.89$, $p=0.014$). Follow-up post-hoc analysis (Duncan's MRT) revealed that the group of homosexual women had significantly lower empathy index scores (Mean$=-1.15$, SD$=0.23$) as compared to the three other groups ($p<0.05$).

In order to further explore the role of sexual orientation in empathy, a correlation analysis was conducted between the empathy index and the KSOG score. This analysis revealed that for women, a trend was found between the empathy scores and the KSOG scores, indicating that higher heterosexual tendencies in women were associated with higher levels of empathy ($r=-0.41$, $p=0.06$). No significant correlation was found for men ($r=0.015$, $p=0.95$).

2.2. Neuroimaging results

2.2.1. Gender and sexual attraction

To determine whether the often-reported gender differences in empathy are due to the sexual attraction of the subjects, we first examined the interaction between the two between subject factors (gender and sexual attraction). This analysis revealed that 0.003% of 106,720 map voxels were activated both for the attraction and the gender main effects for $F(1,5)=7.5$, $p<0.007$. That is, no overlapping brain regions were activated for attraction and gender factors.

To investigate the effects of gender on empathy related activations, group fixed effects general linear model analysis was conducted. A 2×2 ANOVA (gender by protagonist condition) was carried out, with gender (women, men) as the

Table 1 – Peak of activation obtained from whole-brain contrast. Talairach coordinates of regions extracted from the SELF–OTHER contrast (random effect, FDR corrected GLM). (a) SELF > OTHER. (b) OTHER > SELF.

Region	BA	Voxel of peak activation (*x*,*y*,*z*)	F	*p*	# of voxels
a					
L hippocampus		−24,−19,−11	6.41	0.01×10^{-7}	336
L MPFC	10	−3,53,10	14.9	0.01×10^{-14}	43,804
R STG	21	48,−25,−5	5.77	0.01×10^{-7}	1603
R cuneus	18	24,−79,19	5.18	0.000004	1082
R cerebellum		27,−76,−26	5.79	0.01×10^{-7}	2468
L cingulate	24	0,−16,40	7.9	0.01×10^{-9}	5454
L posterior cingulate	30	−6,−58,7	6.95	0.01×10^{-9}	4246
L superior occipital	19	−39,−82,28	7.33	0.01×10^{-9}	2778
L MTG	21	−57,−49,7	8.17	0.01×10^{-11}	11,848
b					
R posterior cingulate cortex	31	12,−64,28	9.57	0.01×10^{-10}	11,605

Stereotactic coordinates and *t* values are provided for local voxel maxima. L=left; R=right; M=middle. MTG – Medial Temporal Gyrus, STG – Superior Temportal Gyrus, MPFC – Middle Prefrontal Cortex.

between subject fixed effect factor, condition (SELF, OTHER) as the within-subjects fixed effect factor, and subject ($N=52$) as the random effect factor. An interaction effect ($p<0.0006$, FDR corrected) between protagonist (SELF, OTHER) and gender (men, women) was evident in several key empathy related brain regions (see Table 2), including the MPFC, posterior cingulate and MTG.

To further examine the main effects in the brain structures activated by the gender factor, a MANOVA was conducted. This analysis was performed on beta weights derived from clusters (each of them regarded as a dependent variable) activated in the gender × protagonist interaction effect, for OTHER condition, with gender as the between subject factor. Main effects for gender were found in the MPFC (BA 11) for the OTHER condition ($F(1,50)=14.69$, $p<0.0001$). The rest of the regions did not show significant effects following correction for multiple analyses. Follow up t-tests revealed that women showed higher beta weights than men the in the MPFC (BA 11) for OTHER condition ($t(50)=3.82$, $p<0.0001$).

Finally, to explore the role of sexual orientation, a one-way ANOVA was conducted for the MPFC (BA 11) for OTHER condition, with sexual orientation as the between-subjects factor. This analysis indicated significant differences between the groups ($F(3,48)=8.69$, $p<0.0001$). Post-hoc Duncan's MRT test indicated that betas for heterosexual women were the highest and significantly different from the three other groups ($p<0.05$).

In order to identify the effects of sexual preference (attraction to men and attraction to women) on empathy related activations, a second-level group analysis was conducted using a fixed-random mixed effects general linear model. A 2 × 2 ANOVA (attraction by protagonist condition) was carried out, with attraction (attracted to men, attracted to women) as the between subject fixed effect factor, condition (SELF, OTHER) as the within-subjects fixed effect factor, and subject ($N=52$) as the random effect factor.

An interaction effect between protagonist (SELF, OTHER) and attraction (attracted to men, attracted to women) was evident in several key empathy related brain regions, including the left TPJ (BA 40) and the MPFC (BA 24, BA 32) ($p<0.0008$, FDR corrected, see Table 3).

In order to further examine the main effects in the brain structures activated by the attraction factor, a MANOVA was conducted for the beta weights derived from clusters activated in the attraction × protagonist interaction effect, for OTHER condition, with attraction as the between subject factor. Main effects for attraction were found in the TPJ for the OTHER condition ($F(1,50)=11.9$, $p=0.001$). The rest of the effects did not survive the corrections for multiple analyses. Follow up t-tests revealed that individuals attracted to men showed higher beta weights than individuals attracted to women in the in the TPJ for OTHER condition ($t(50)=3.45$, $p=0.001$). In order to further explore the effects of gender and sexual orientation on empathy-related activations, a one-way ANOVA was conducted for the TPJ for OTHER condition, with sexual orientation as the between-subjects factor. This analysis indicated significant differences between the groups ($F(3,48)=4.13$, $p=0.01$, see Fig. 2). Post hoc Duncan's MRT reveals that the heterosexual women were significantly different from the heterosexual men and homosexual women. Furthermore, the heterosexual men are not significantly different from the homosexual women ($p<0.05$).

To rule out the possibility that the handedness of subjects had an effect on the results (10 of the participants were left handed), the ANOVA was performed for the TPJ for OTHER condition with sexual orientation and handedness as the between-subjects factors. This analysis indicated that the difference between groups remained significant ($F(7,44)=2.75$, $p=0.2$), ensuring that handedness did not affect the reported group differences.

2.3. *Brain and behavior*

Following the finding that the left TPJ showed sensitivity to the OTHER emotional state, its role was further explored using a correlation analysis between this region and the empathy index. This analysis revealed a significant correlation between the beta weights for the TPJ OTHER and the behavioral empathy index ($r=0.373$, $p=0.006$), indicating that the higher the emotional ratings of the other, the more active the TPJ was while thinking about the other. The same

Table 2 – Peak of activation obtained from whole-brain analysis. Talairach coordinates of regions extracted from the 2 × 2 ANOVA (gender by protagonist condition), with gender as the subject fixed effect factor, condition (SELF, OTHER) as the within-subjects fixed effect factor, and subject (N=52) as the random effect factor. Clusters taken from the interaction effect between protagonist (SELF, OTHER) and gender (men, women), random effect, FDR corrected GLM.

Region	BA	Voxel of peak activation (x,y,z)	F	p	# of voxels
R posterior cingulate	23	11,−38,23	1.8	0.01×10^{-8}	316
L MPFC	10	−6,64,1	2.24	0.01×10^{-11}	1801
L MPFC	11	−44,36,−14	5.04	0.01×10^{-9}	739
L MTG	21	−55,1,−10	3.46	0.01×10^{-8}	1490

Stereotactic coordinates and t values are provided for local voxel maxima. L=left; R=right; M=middle. MTG – Medial Temporal Gyrus, MPFC – Middle Prefrontal Cortex.

Table 3 – Peak of activation obtained from whole-brain analysis. Talairach coordinates of regions extracted from the 2 × 2 ANOVA (attraction by protagonist condition), with attraction as the subject fixed effect factor, condition (SELF, OTHER) as the within-subjects fixed effect factor, and subject (N=52) as the random effect factor. Clusters taken from the interaction effect between protagonist (SELF, OTHER) and sexual attraction (attracted to men, attracted to women), random effect, FDR corrected GLM.

Region	BA	Voxel of peak activation (x,y,z)	F	p	# of voxels
R MPFC	32	26,37,10	6.84	0.01×10^{-7}	3607
L MPFC	32	−21,29,19	8.01	0.01×10^{-7}	2986
L SFG	24	−10,63,23	6.21	0.01×10^{-7}	607
R precuneus	7	20,−52,42	5.7	0.01×10^{-7}	262
L MPFC	32	−12,45,10	5.98	0.01×10^{-7}	522
L TPJ	40	−45,−29,23	6.21	0.01×10^{-7}	261
L cuneus	19	−25,−82,28	5.86	0.01×10^{-7}	632
L medial occipital gyrus	19	−43,−73,3	5.64	0.01×10^{-7}	1105

Stereotactic coordinates and t values are provided for local voxel maxima. L=left; R=right; M=middle. SFG – Superior Frontal Gyrus, MPFC – Middle Prefrontal Cortex, TPJ – Temporo-Parietal Junction.

analysis was carried out with the MPFC region and did not yield any significant result ($r=0.054$, $p=0.7$).

To examine the relationship between sexual orientation and TPJ activity, a correlation analysis was conducted between the beta weights derived from the TPJ OTHER and the subjects' KSOG scores. Correlations were calculated for each gender separately. Results showed a trend so that among men a trend of higher ratings of homosexuality were related to higher left TPJ activity($r=0.39$, $p=0.06$). No significant result was found for women ($r=-0.33$, $p=0.12$). The difference between the two correlation coefficients was tested and found to be significant ($z=-2.56$, $p=0.005$).

2.3.1. *SELF versus OTHER*

To determine empathy related activations across all groups a whole-brain contrast was performed between the SELF and OTHER protagonist conditions. As shown in Fig. 3, this analysis revealed a wide network showing increased activation during emotional judgment of the self as compared to judgment of others (SELF > OTHER) including the MPFC, hippocampus and cingulate cortex ($p<0.01 \times 10^{-7}$, FDR corrected, see Table 1a). Increased activation during emotional judgment of others (OTHER > SELF) involved a network including the posterior cingulate cortex (PCC) ($p<0.01 \times 10^{-10}$, FDR corrected, see Table 1b). Conjunction analysis between SELF > rest and OTHER > rest revealed brain activations in fronto parietal and occipital and mid brain regions.

3. Discussion

The present study investigated the behavioral and neural characteristics of empathy as manifested by subjects from different sexual orientation groups. Brain-related empathy activations were measured in women and men with a clear homosexual or heterosexual preference who were undergoing a mentalizing task comprising of emotional mentalizing about the self versus another protagonist.

Our data show that at the behavioral level, individuals attracted to men (homosexual men and heterosexual women) show more empathy than subjects attracted to women (heterosexual men and homosexual women). Moreover, we found that empathy levels are significantly higher in heterosexual women than in homosexual women. Interestingly, our data show that men score higher on empathy than women. This may be explained by the use of four equal homogenous sexual orientation groups. Thus, the extremely low empathy scores of the homosexual women on one hand and the high empathy scores of the homosexual men may account for the unexpected superiority of men in the empathy task reported here. The brain imaging data reveal increased activations in self related areas such as the MPFC and the hippocampus when contrasting emotional judgment of self versus other. Furthermore, we found that particularly the MPFC was sensitive to the gender of the subject such that women tended to show more activity in this region as compared to men. The MPFC has been shown repeatedly to mediate perspective taking (D'Argembeau et al., 2007), mentalizing (Assaf et al., 2009; Perry et al., 2011; Denny et al., 2012) and empathy (Meyer et al., 2012), which suggest that women tend to use this region more than men when empathizing. Moreover, sexual orientation, a similar pattern to the behavioral findings was found. Empathy-related structures, such as the MPFC and the left TPJ, show sensitivity to the grouping of the subjects based on their sexual preference. These regions have been shown to be critical for self–other decoding (Denny et al., 2012), which enables self–other awareness, a vital component of empathy (Decety and Jackson, 2004). Further analysis indicated that particularly the TPJ is differentially activated in individuals attracted to men versus individuals attracted to women. Specifically, a significant effect for sexual orientation was found in the left TPJ when the subjects were judging the emotional state of the other, with its activation being the lowest for homosexual women as compared to the three other groups. Furthermore, the activation in this region was significantly associated with the level of empathy toward the other, such that the more active the TPJ, the more the subjects were empathizing.

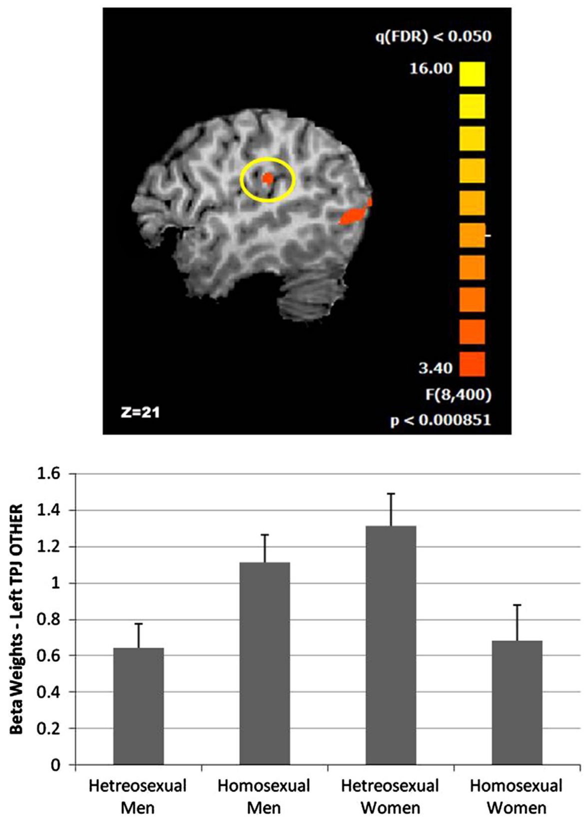

Fig. 2 – (a) Left TPJ region (encircled in yellow) revealed by the main effect for "attraction" (uncorrected). (b) Mean left TPJ beta weights for OTHER condition across sexual orientation groups.

It has been suggested that the TPJ is a part of a network which allows for the mental separation of one's own perspective from that of another person and thus enables us to disentangle our own feelings from those observed in other people (Schulte-Ruther et al., 2008). The sensitivity of the TPJ to the emotional mental state of the other observed here corresponds to other studies that show activation in this region in tasks that involve empathy and mental states attribution (Young et al., 2010). Though not part of the core empathy network (Fan et al., 2011; Lamm et al., 2011), it has been demonstrated that TPJ may be selectively involved in representing and inferring the mental states of others (Saxe, 2006) and that left TPJ lesions impair mental state inference (Samson et al., 2004). Here also we found that left lateralized TPJ activation predicts levels of empathy in the task.

The right TPJ and the posterior part of the Superior Temporal Sulcus have been repeatedly reported to be involved in the representations of others' behavior (Blakemore and Frith, 2003; Decety and Jackson, 2004; Decety and Grezes, 2006), studies of agency (Decety and Grezes, 2006) as well as in mirror neuron activity (Chong et al., 2008). It is important to note here that in this study the activated region within the TPJ was the left BA 40, an area which lies on the border of the inferior parietal lobule and the TPJ, not quite the typical TPJ activation found in theory of mind studies. We suggest that this region has a pivotal role in empathic processes and that its activity is affected by one's sexual preference.

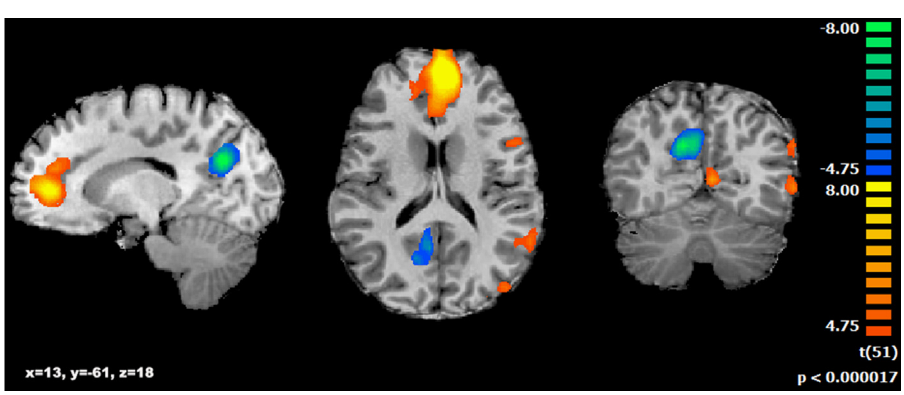

Fig. 3 – Whole-brain activation patterns obtained for the contrast "SELF–OTHER" superimposed on sagittal, axial and coronal anatomical slices ($N=52$, random effect, FDR corrected GLM analysis). Orange represents SELF related activations and in blue – OTHER related activations.

The present study provides direct behavioral and neural evidence supporting the hypothesis that sexual preference modulates empathic abilities. Notably, the results from this study were more evident among women than among men, suggesting that the behavioral and neural differences between heterosexual and homosexual women with regard to empathy to the other are much more prominent than the differences between heterosexual and homosexual men.

While functional and structural brain differences between men and women have been widely reported, neuroanatomical, functional and neurochemical differences between homosexual and heterosexual men and women have yet to be investigated. A few conflicting studies propose that sexual orientation and preference are associated with anatomical and neurochemical brain differences (Ponseti et al., 2007; Rametti et al., 2010; Liu et al., 2011; Rametti et al., 2011). Kranz and Ishai (2006) have found that within the neural circuitry for reward, heterosexual men and homosexual women respond more to female face than male face, while heterosexual women and homosexual men show the reverse pattern and prefer male faces. In line with this, it has been reported that homosexual women have experienced higher prenatal testosterone level which may be assessed by the second to fourth finger lengths ratio (or 2D:4D ratio) compared to heterosexual women. Furthermore, Chapman et al. (2006) have found a negative correlation between empathic abilities and prenatal testosterone levels. It has also been demonstrated that administration of testosterone in women led to a significant impairment in their empathy, and that this effect is powerfully predicted by their 2D:4D ratio (Van Honk et al., 2011).

Given that empathy is considered a feminine trait (Brody, 1985) and that homosexual men have been reported to possess more feminine behavior entities than heterosexual men (Rieger et al., 2010) it is not surprising that individuals attracted to men show higher empathy levels. Accordingly, Salais and Fischer (1995) report that homosexual males display significantly higher levels of empathy as compared to heterosexual men. Our findings regarding lower levels of empathy among homosexual women as compared to heterosexual women may be explained in the context of the former group's similarity to heterosexual men (Gettelman and Thompson, 1993; Drummond et al., 2008).

Yet, an equally plausible explanation may be based on learning theory principles. The attraction to either gender usually signifies with which gender a person shares the most intimate and close relationships. Hence, it is possible that the object to which we direct our mating strategies may affect our empathic abilities. As such, subjects attracted to a specific gender, whether heterosexual or homosexual, might share commonalities in their social skills based on their relationship past experiences (Deaux and Major, 1987).

A limitation of the current design is the difference in genders of the protagonist. Homosexual and heterosexual men judged the emotional states of men while homosexual and heterosexual women judged the emotional states of women. This design was planned to minimize variability so that each subject would judge a protagonist from his own gender. Yet, this may be problematic as homosexuals actually judged the emotional states of other potential sexual attraction objects, while heterosexual subjects judged others not belonging to their sexual attraction object group. Thus, it is important to further examine the current research question using matched and unmatched protagonists. Furthermore, in the current study, subjects used their imagery skills to imagine and put together their protagonist. Future studies should investigate if some of the current results can be explained by imagery capacities and not empathy per se.

4. Conclusion

We show here that subjects differ on their empathic abilities depending on their sexual preference such that subjects attracted to men empathize to a higher degree than subjects attracted to women. These results indicate that individual differences in empathy may be modulated by one's sexual preference. Hence, sexual orientation and preference are important when examining individual differences in empathy.

5. Experimental procedures

5.1. *Participants*

Participants were 52 healthy individuals, ranging in age from 22–36 (mean age: 28.46, SD=3.4). The recruitment of subjects was carried out through an ad and was based on a screening which included a self-report questionnaire involving direct questions regarding the sexual orientation of the participant (heterosexual/homosexual). Following the screening, the participants were grouped into two sexual preference groups and were invited to the scanning session. Subjects were included only if they showed a clear sexual preference to one sex (bisexual individuals were excluded from the study). Exclusion criteria included psychiatric or neurological conditions. The group that reported being attracted to women consisted of 25 subjects, including 13 heterosexual men and 12 homosexual women. The group that reported being attracted to men consisted of 27 participants, including 12 homosexual men and 15 heterosexual women. Ten subjects were left-handed (4 heterosexual men, 2 homosexual men, 2 heterosexual women, and 2 homosexual women). There was no age difference between the groups ($F(3,42)=0.199$, $p=0.658$). Participants had no reported history of psychiatric or neurological disorders and were not using psychoactive drugs at the time of the study. In addition, all participants had normal or corrected-to-normal vision. All subjects gave informed consent and were paid for their participation.

5.2. *Instruments*

Following scanning participants completed the Klein Sexual Orientation Grid (Klein, 1993) to further assess levels of homosexuality and heterosexuality. The Hebrew version of the Klein Sexual Orientation Grid (KSOG) (Klein, 1993), assesses seven dimensions of sexual orientation tendencies, including sexual preference, sexual behavior, sexual fantasies, emotional preference, social preference, self-identification, and heterosexual/homosexual lifestyle. The items are rated on a seven-point scale, with 1 depicting opposite sex tendencies and 7 depicting same sex tendencies. On each dimension, the subjects are asked to mark their past attitude (prior to the last year), their present attitude (in the last six months), and what they believe to be the ideal attitude. Using this measure, we confirmed subjects' sexual preference. The mean KSOG score of the heterosexual men was 44.08, SD=11.4 and of the homosexual men was 119.00, SD=9.65. As for women, the mean score for the heterosexual group was 45.40, SD=10.49 and the homosexual group was 101.75, SD=10.28. KSOG scores for the four groups were normally distributed (heterosexual men: $W=0.976$, $p=0.942$, homosexual men: $W=0.928$, $p=0.392$, heterosexual women: $W=0.909$, $p=0.387$, homosexual women: $W=0.937$, $p=0.463$). The data of the KSOG of six subjects was lost due to a technical reason and unavailable for data analysis.

5.3. *Stimuli and procedure*

In order to examine the hypothesis that individual differences in empathy may be related to sexual preference, we designed an emotional judgment task in which subjects rated the emotional magnitude of events happening to another protagonist ("OTHER" condition) or to themselves ("SELF" condition, Fig. 1). It was reasoned that the difference between the emotional ratings for the SELF and the OTHER protagonists would reflect the degree of the tendency to self-project the emotional state of others (Perry et al., 2011). Thus, an empathy index was created by calculating the ratio between the ratings for SELF and OTHER protagonists.

Pre-scanning: The empathy tasks included judgments of emotional events happening to two protagonists: "SELF" and "OTHER". Subjects were presented with short vignettes depicting different protagonists in order to familiarize them with the OTHER protagonist (for an example see Fig. 4). The vignettes matched the sexual orientation of the subject so that heterosexual men read short stories about heterosexual male characters, homosexual men read about homosexual men, and so forth. One character from the vignettes was chosen by the experimenter to be part of the scanning session.

Vignette example - Hetreosexual Men

Asaf was born in Jerusalem in 1978. He graduated from the Academy of Arts and sciences in Jerusalem and now he studies cinematography in the Sam Spiegel institute. Asaf rents a small apartment in central Jerusalem. He plans to finish his studies by the end of 2012 and meanwhile he works during the nights in the local café. Then, he plans a long trip to South America with Ronit, his girlfriend. His parents got divorced ten years ago. His father remarried two years ago, and his mother lives with his 20 years old younger brother. Asaf's hobbies are: painting (he goes to an evening class once a week), movies and shooting pool. In the last few weeks, Asaf is helping Alon, his best friend, to organize his proposal to Michal. They make a video clip for the occasion.

Asaf is an extrovert kind of guy. He has a large circle of friends around him and succeeds to maintain many close relationships over the years. He never forgets birthdays and always calls to congratulate. His special Purim (Jewish holiday) parties are known all around.

He has close relationships with his family members and his younger brother often comes over for the weekend to hang out. Asaf is living a very intensive daily routine and has always the need for new adventures which is translated to vacation around the world whenever it's possible.

Fig. 4 – An example of vignette given to subjects from the hetreosexual men group.

Scanning: The stimuli consisted of 120 sentences depicting everyday emotional events happening to either the subject ("SELF" condition) or another protagonist ("OTHER" condition). The experiment was divided into four counterbalanced runs of 7.25 min each, with 30 sentences presented in a pseudo-random manner in each run. The sentences were presented visually in a slow event-related fashion. After the presentation of each sentence, participants were instructed to judge the emotional intensity of the event using a cursor that moved along a judgment bar, ranging from 5=highest joy to −5=highest distress. Participants were instructed to read the sentences and rate the amount of emotional intensity that would be felt by the protagonists (SELF, OTHER) in such a situation. Event length varied from 2.5 to 7.5 s. During the first 2.5 s, subjects had to read the sentence and indicate whether the event was distressful or joyful by clicking on one of two keys. Following this initial response, the cursor started to move to the left or to the right along the judgment bar. The subjects then had to estimate the intensity of the emotion by another click, which stopped the cursor from moving at a point between 0 and 5 and ended the event. The sides of the judgment bar were switched between subjects in a counterbalanced manner. Between events there were rest époques that lasted from 5 to 10 s, depending on the length of the preceding event. Each event was followed by a blank screen with a fixation point.

5.4. *fMRI image acquisition and analysis*

Scanning was performed in a 3T GE scanner with an 8-channel head coil, using a gradient echo-planar imaging (EPI) sequence of functional T2*-weighted images (TR/TE/flip angle: 2500/35/90; FOV: 20 _ 20 cm^2; matrix size: 64 _ 64) divided into 40 axial slices (thickness: 3 mm; gap: 0 mm) covering the whole cerebrum. Anatomical 3D-sequence spoiled gradient (SPGR) echo sequences were obtained with high-resolution 1-mm slice thickness (FOV: 25 _ 18; matrix: 256 _ 256; TR/TE: 9/3.6 ms). The fMRI data were processed using the BrainVoyager QX 2 software package (http://www.brainvoyager.com).

Pre-processing of functional scans included head movement assessment, high-frequency temporal filtering, and removal of low-frequency linear trends. Scans with head movements >1.5 mm were rejected. In order to allow for T2* equilibration effects, the first six images of each functional scan were rejected. Pre-processed functional images were incorporated into the 3D datasets through trilinear interpolation. The complete dataset was transformed into Talairach space. Three-dimensional statistical parametric maps were calculated separately for each subject using a general linear model (GLM), in which both stimuli conditions (SELF, OTHER) were positive predictors, were convolved with a hemodynamic response function. Finally, spatial smoothing was applied (FWHM: 4 mm). False Discovery Rate (FDR) correction method was used for the multiple comparisons problem. Beta weights extraction was performed from the whole cluster activated.

5.5. *Statistical analysis*

To investigate this study's hypotheses we first computed an empathy index based on the ratio between emotional ratings for SELF and OTHER protagonists. ANOVA was conducted on this index with 'gender' and 'attraction' as the between-subject factors. Then, this index was correlated with the KSOG scores. To look for brain correlates, we first conducted a qualitative analysis to look for brain regions which show sensitivity both to the gender and sexual attraction main effects. Then we ran a second level group analysis with 'gender' as the between subject factor. Following this, a MANOVA was conducted for the regions revealed by the group analysis. Afterward, a second group analysis was conducted, this time with 'sexual attraction' as the between group factor. Here, again followed a MANOVA for the regions revealed by the second group analysis. Finally, brain and behavior correlations were explored using the empathy index, KSOG score and TPJ beta weights.

Author contributions

The authors declare no conflict of interest.

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