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Identifying with fictive characters: structural brain correlates of the personality trait ‘fantasy’

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The perception of oneself as absorbed in the thoughts, feelings and happenings of a fictive character (e.g. in a novel or film) as if the character's experiences were one's own is referred to as identification. We investigated whether individual variation in the personality trait of identification is associated with individual variation in the structure of specific brain regions, using surface and volume-based morphometry. The hypothesized regions of interest were selected on the basis of their functional role in subserving the cognitive processing domains considered important for identification (i.e. mental imagery, empathy, theory of mind and merging) and for the immersive experience called ‘presence’. Controlling for age, sex, whole-brain volume and other traits, identification covaried significantly with the left hippocampal volume, cortical thickness in the right anterior insula and the left dorsal medial prefrontal cortex, and with gray matter volume in the dorsolateral prefrontal cortex. These findings show that trait identification is associated with structural variation in specific brain regions. The findings are discussed in relation to the potential functional contribution of these regions to identification.

Keywords: identification; brain; fantasy; empathy; personality; MRI

INTRODUCTION

The experience of losing oneself in the fictive happenings of a novel, movie, video game or virtual reality environment has long evoked reflection and research interest (e.g. Balazs, 1995; Horton and Wohl, 1956; Maccoby and Wilson, 1957; Tellegen and Atkinson, 1974; Sheridan, 1992). This experience can be so strong that a person perceives him or herself as responding in thought, feeling and behaviour to fictive situations, events and characters as if these were in some way real (Lombard and Ditton, 1997), with some individuals experiencing this more strongly than others (e.g. Dal Cin *et al.*, 2002; Wirth *et al.*, 2007). One kind of this experience is character ‘identification’ (Cohen, 2001; for other kinds, see e.g. Tan, 1996; Green *et al.*, 2004; Jancke *et al.*, 2009). Identification refers to the transient experience of imaginatively perceiving oneself as transposed into the thoughts, feelings and situations of a media character, experiencing the character's happenings from the character's perspective, and of merging with or being that character (Oatley, 1995, 2002; Cohen, 2001, 2006; Moyer-Guse, 2008; de Graaf *et al.*, 2009; Igartua, 2010).

Very little is understood about the structural and functional brain underpinnings of identification. The ‘fantasy’ scale of the well-validated self-report Interpersonal Reactivity Index (IRI) (Davis, 1996) is considered a measure of the disposition to identify with fictive characters (e.g. Hall and Bracken, 2011; Mooradian *et al.*, 2011; Gilet *et al.*, 2012). A recent study used the ‘fantasy’ scale and the other IRI scales (i.e. perspective taking, empathic concern, and personal distress) to investigate the structural correlates of empathy (Banissy *et al.*, 2012). Banissy *et al.* report that the scores of the fantasy scale are associated with gray matter density of the dorsolateral prefrontal cortex (DLPFC). Reflecting the aims of that study, their a priori regions of interest (ROIs) were selected on the basis of functional neuroimaging data from studies of theory of mind (TOM) and empathic concern.

Although these are relevant for identification (as considered in the following), further aspects of identification and their potential structural correlates can be considered.

Processes associated with TOM are thought to make a contribution to the experience of identification (Cohen, 2001; Igartua, 2010). TOM entails imaginatively assuming the perspective and explicitly inferring or evaluating the mental state and feelings of another person (Singer and Lamm, 2009; Fan *et al.*, 2011). An important aspect of TOM (and empathic concern) is that the ‘self-other distinction’ is maintained (e.g. Decety and Lamm, 2007) so that cognitive representations of the mental state and feelings of the other person can be attributed correctly to the other and not to oneself (Decety and Jackson, 2004). In identification, a fictive character's experiences are perceived from the character's perspective as if they are really happening to the media user, this including the perception of adopting the character's role, plans, traits, beliefs, goals and emotions (Davis, 1996; Oatley and Gholamain, 1997; Cupchik *et al.*, 1998; Cohen, 2001; Tal-Or and Cohen, 2010; Mar *et al.*, 2011). This feature of identification has been referred to as merging or ‘self-other merging’ (Kaufman and Libby, 2012). Kaufman and Libby argue on the basis of behavioural data that self-other merging is associated with the maintenance of representations of the other and reduced activation of representations of self that would normally be required for perspective taking (see also Davis, 1996; Igartua and Paez, 1998; Cohen, 2001; de Graaf *et al.*, 2009; Tal-Or and Cohen, 2010). The principal areas associated with TOM are the dorsal medial prefrontal cortex (dMPFC) and the right temporoparietal junction (TPJ) (e.g. Saxe and Wexler, 2005; Buckner *et al.*, 2008). These areas might also be involved in coordinating and contrasting cognitive representations of self and other during identification. The TPJ plays a key role in distinguishing self from other and the dMPFC is closely associated with other processing and monitoring (including monitoring of fictive characters) in a range of tasks (e.g. Decety and Sommerville, 2003; Farrer *et al.*, 2003; Frith, 2005; Mason and Just, 2009).

Processes associated with empathy are also thought to make a contribution to the experience of identification (Cohen, 2001; Igartua, 2010). Empathy entails automatically sharing and implicitly generating a representation of another's affective state and is considered to be an important component of empathic concern (e.g. Decety and Jackson, 2004).

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Neuroimaging studies of affect sharing in the context of empathic concern (e.g. Singer *et al.*, 2004) show that the mere observation or imagination of another's affective state is sufficient to evoke activation in brain regions associated with a number of shared emotions. The involvement of the anterior insula (AI) and anterior cingulate cortex (ACC) in sharing various affective states has been most consistently reported (e.g. Fan *et al.*, 2011). Based on their meta-analysis, Fan *et al.* suggest that these regions are likely to be associated with processes required for simulating these states.

Mental imagery is a key component of identification (Cohen, 2001; Igartua, 2010). The use of mental imagery to simulate a character's experiences entails imaginative construction and elaboration of the narrated events and situations of the character in a cohesive situation model of the mediated world (Kintsch and van Dijk, 1978; Oatley, 1999a). This enables a coherent sense of a narrative and a character's experiences within and across inter-related scenes and events to be maintained (Polichak and Gerrig, 2002; Mar and Oatley, 2008). Hassabis and Maguire (2009) propose a 'construction system network' of brain regions involved in the generation and representation of complex imaginary simulations or scenarios. Andrews-Hanna *et al.* (2010) identify a similar brain network ['medial temporal lobe (MTL) sub-system' of the brain's default system; for a review of the default system, see Buckner, 2008], the underlying function of which is also considered to entail mental simulation of imaginary scenarios. Though not supporting processes of mental simulation alone, the hippocampal formation (HF) is a critical component of these two networks. The HF is associated with the initial generation and ongoing elaboration of complex imaginary scenarios that can be set temporally in the past, present and future and can flexibly use and combine information drawn from fictive and autobiographical sources (e.g. Schacter *et al.*, 2008; Hassabis and Maguire, 2009); elaboration of fictive narrative with autobiographical information can enhance perception of oneself as transposed into narrative (Larson and Laszlo, 1990).

The aim of this study was to examine whether individual variation in structural morphology of the brain is associated with individual differences in the predisposition to experience identification. Like Banissy *et al.* (2012) we used the 'fantasy' scale of the IRI. We also controlled for the effects of variation in the other IRI scales in order to tease out the variation in structural brain morphology specifically associated with identification. Following Banissy *et al.*'s approach provides a good basis for comparison of findings, but we expanded on their study in four ways. Firstly, we considered the facets of identification (i.e. mental imagery, TOM, empathy, merging) as a basis for hypothesizing brain regions likely to be associated with the scores of the fantasy scale; we did not seek to investigate how these regions are specially associated with each facet of identification. Second, we examined the relationship between trait identification and gray matter density using voxel-based morphometry (VBM) to replicate Banissy *et al.*'s (2012) finding, and we applied also surface-based morphometric methods to examine this relationship in terms of cortical thickness (CT). We took this dual approach because each technique has its strengths and weaknesses (MacDonald *et al.*, 2000; Ashburner and Friston, 2001; Bookstein, 2001; Kim *et al.*, 2005). We used in addition volumetric segmentation to examine the hippocampus. Third, given that the IRI-based measures of identification rely on self-reports of subjective experience in relation to media exposure (movies and novels), we analysed the relationship between trait identification and the occurrence of trait-congruent behaviour and the relationship between this behaviour and variation in structural morphology. Finally, we extended Banissy *et al.*'s (2012) examination of identification-related structural variation in the DLPFC to consideration of further ROIs within the right and left DLPFC. These additional ROIs were identified by Baumgartner *et al.* (2008) as pivotally involved in

modulating the subjective immersive experience of 'presence'. Presence refers to the transient perception of oneself as situated in and able to act in a fictive world mediated by virtual reality technology (Sanchez-Vives and Slater, 2005). We examined whether these presence-related regions are also relevant for identification. Based on the preceding, we anticipated that variation in trait identification would be associated with variation in the structural morphology of HF, AI, ACC, TPJ, dMPFC and different regions within the DLPFC.

METHODS

Participants

Thirty-eight right-handed students of Zurich University and native speakers of Swiss- or Standard German (19 females, mean age = 27.2 years, s.d. = 6.09; and 19 males, mean age = 27.6 years, s.d. = 6.52) with no record of neurological or psychiatric illness or use of psychoactive drugs participated. Each received 20 Swiss Francs and gave written informed consent before participation according to the guidelines of the Declaration of Helsinki. The local Ethics Committee approved the study, procedures and consent forms.

Personality measure

The 'fantasy' scale of the Saarbrücker Persönlichkeitsfragebogen (SPF) [Paulus, 1992; German version of the IRI (Davis, 1996)] was used to measure the degree of identification with characters in fictional situations in novels and movies (e.g. Mestre *et al.*, 2004; Poulos *et al.*, 2004; Konrath *et al.*, 2011; Fernández *et al.*, 2011; Hall and Bracken, 2011; Mooradian *et al.*, 2011; Gilet *et al.*, 2012). The other SPF scales measure empathic concern (i.e. prosocial feelings of warmth, compassion and concern for others), perspective taking (i.e. spontaneous adoption of another's psychological vantage point and viewing of situations and events from that perspective) and personal distress (measuring self-oriented feelings of anxiety and discomfort in response to the distress of others). Paulus validated the SPF against a selection of other German measures and was able to improve the psychometric properties of each SPF scale by omitting the negatively formulated items of the original IRI. Each scale of the SPF has therefore four items. (See the [Supplementary Information S1](#) for the items of the fantasy scale.) Responses are measured on a five-point Likert scale that ranges from 'description does not apply to me at all' to 'description applies to me very well'. The lowest score on each scale is 5 and the maximum is 20. The alpha coefficients of the SPF scales are good, ranging from 0.66 to 0.74, and the split-half coefficient with Spearman-Brown correction achieves a very good value of 0.80 (Paulus, 2006). Cronbach's alpha for the scales in this study and especially for fantasy was generally high (fantasy: 0.83; personal distress: 0.70; empathic concern: 0.62; perspective taking: 0.65). Participants were invited for the MRI session on another day.

As the fantasy scale of the SPF relates to movie going and book reading behaviour, data were collected from participants on their media consumption. Participants were asked to carefully consider the number of novels read and movies seen in the cinema over the year preceding data collection. They also provided information as to the hours typically spent watching television and playing video games in a week over the year preceding data collection. These data were used to calculate television and video game consumption for the year.

Data acquisition

MRI scans were acquired using a 3.0 T Philips Achieva whole-body scanner (Philips Medical Systems, Best, The Netherlands). A 3D T1-weighted gradient echo sequence (fast field echo) scan was obtained for each participant. For each scan, slices were acquired in the sagittal plane with a measured and reconstructed spatial resolution of

$0.94 \times 0.94 \times 1.00 \text{ mm}^3$ (matrix 256×256 pixels, 160 slices). Further imaging parameters were: field of view = $240 \times 240 \text{ mm}^2$, echo-time = 3.7 ms, repetition-time = 8.06 ms, flip-angle $\alpha = 8^\circ$ and SENSE factor = 2.1. Scan time was about 8 min.

Regions of interest

For analyses, a priori hypotheses were postulated for brain regions likely to be associated with trait identification. These ROIs were HF, AI, ACC, TPJ, dMPFC and DLPFC. These were determined on the basis of findings referred to in the introduction. With the exception of the hippocampal volumes and its subfield volumes, the results reported are based on whole-brain analyses.

Data pre-processing

Surface-based morphometry (SBM, FreeSurfer software, <http://surfer.nmr.mgh.harvard.edu/>) was used to model each participant's cortical surface to measure CT and FreeSurfer's automated subcortical segmentation procedure was used to measure hippocampal and its subfields volumes. Voxel-based morphometry VBM8 toolbox (<http://dbm.neuro.uni-jena.de/vbm/>) implemented in SPM8 (Wellcome Department of Cognitive Neurology, London, UK; <http://www.fil.ion.ucl.ac.uk/spm/>) was applied in addition to replicate the finding of trait identification and gray matter volume in the DLPFC in a study that used VBM (Banissy et al., 2012).

The SBM pre-processing steps included extraction of brain data, exclusion of non-brain tissue from the brain image and co-registration of the brain image to the sample average. Maps for CT were ascertained for each participant and brain images re-sampled into a common spherical coordinate system that is aligned with the Montreal Neurological Institute (MNI) space. Image smoothing along the cortical surface used a 10 mm full-width-at-half-maximum Gaussian kernel was applied. (See the [Supplementary Information S2](#) for further details of cortical surface reconstruction, thickness measurement and volumetric hippocampal segmentation.) The smoothed CT maps were used as the dependent measure in a vertex-wise general linear model across the whole cortical surface to determine co-variation between CT and individual fantasy scores. The volume of the right and left hippocampus of each participant was determined and extracted for analysis in SPSS (Version 17.0) to analyse the relationship between hippocampal volume and identification. We also explored the potential role of individual regions (subfields) within the hippocampus. (See the [Supplementary Information S3](#) for further details of hippocampal subfield segmentation and volume estimation.)

For the VBM pre-processing, we used default estimation settings, but write out segments modulated for both linear and non-linear normalization terms. In short, raw MR images were bias field corrected, tissue class segmented and spatially normalized into the MNI space using DARTEL. In addition, grey matter segments were modulated by the Jacobian determinant and smoothed with a Gaussian kernel of $9 \times 9 \times 9 \text{ mm}$ FWHM.

Main statistical analyses

Multiple regression analyses (partial correlations) were applied to the FreeSurfer and SPM data, and partial correlative analysis in SPSS was used. We controlled for the effects of gender and empathic concern, perspective taking, and personal distress to ensure that the identification-related effects were independent of inter-individual variation in the other SPF scales and to account for the found gender differences in personal distress. To replicate their finding and maintain consistency with Banissy et al.'s (2012) analyses, we also controlled for hemispheric mean global CT and total grey matter volume in the analyses for local CT and local grey matter volume, respectively.

Given our specific ROI hypotheses, a vertex height threshold of $P < 0.01$ uncorrected for multiple comparisons and a cluster extent threshold of $k > 75 \text{ mm}^2$ was applied in the FreeSurfer analysis to protect against spurious results because false-positive results do not cluster in space (e.g. Forman et al., 1995; Lieberman and Cunningham, 2009). We also corrected for multiple comparisons using more conservative nonparametric Monte Carlo simulations at the cluster extent. The data did not survive multiple comparison correction, meaning that the reported data are uncorrected.

For the volumetric gray matter analyses in SPM, a voxel height threshold of $P < 0.001$ uncorrected for multiple comparisons and a voxel extent threshold of $k > 100$ voxels were applied. SPM's small volume correction procedure (Worsley et al., 1996) with a radius of 10 mm centred on the local maxima after passing a whole-brain uncorrected threshold of $P < 0.001$ combined with a FWE correction procedure with $P < 0.05$ was applied. To replicate the finding reported by Banissy et al. (2012) for DLPFC, we applied the same statistical model as they used. In a whole-brain approach, we correlated the fantasy score with voxel-wise grey matter volume while simultaneously correcting for global grey matter volume, age, gender, empathic concern, perspective taking and personal distress. A small volume correction analysis of DLPFC was constrained to the MNI coordinates: $x = 40$, $y = 47$, $z = 30$ (Banissy et al., 2012).

For the analyses of associations between fantasy and hippocampal volume and the hippocampal subfield volumes, we corrected, in keeping with the preceding analyses of CT and gray matter volume, for global grey matter volume, gender, empathic concern, perspective taking and personal distress. Error probability was set to $P < 0.05$.

For descriptive purposes, we also extracted cluster or peak information of the findings and present them as scatter plots in the [Supplementary Information S4](#).

In addition to the a priori defined ROIs (HF, AI, ACC, TPJ, dMPFC and DLPFC), we explored in whole-brain analyses of CT and cortical volume whether further regions associated with the brain networks of the construction system network (Hassabis and Maguire, 2009), the MTL default subsystem and dorsomedial PFC default subsystem (Andrews-Hanna et al., 2010) might be relevant for trait identification. These additional regions for exploration included lateral temporal cortex and temporal pole (Andrews-Hanna et al., 2010), the ventral medial prefrontal cortex, posterior inferior parietal lobule, retrosplenial cortex and parahippocampal cortex (Hassabis and Maguire, 2009; Andrews-Hanna et al., 2010), as well as middle cingulate cortex and inferior frontal gyrus (IFG) (Fan et al., 2011). The exploratory findings are reported in the Results section. For completeness, all regions identified in analyses are reported in [Table 3](#).

RESULTS

Personality questionnaire

There were no significant correlations between the scores of the four scales of the SPF (the scores for male, female and all participants are shown in [Table 1](#)). As sex differences between the original IRI scales have been reported (Davis, 1980), *T*-tests were used to determine whether there were any such differences between the SPF scales (testing for significance at $P < 0.05$). A highly significant gender effect was found for personal distress only, $t_{36} = -3.70$, $P = 0.001$, with female participants ($M = 10.61$; *s.d.* = 1.94) reporting greater distress than male participants ($M = 8.06$; *s.d.* = 2.18). Personal distress was already planned to be entered as an additional control variable in the analyses of structural morphology.

Table 1 Mean score and standard deviations on each SPF scale for male, female and all participants

SPF subscale	Male participants	Female participants	All participants
Fantasy	13.26 (3.66)	15.32 (3.01)	14.29 (3.46)
Perspective taking	15.16 (2.67)	15.95 (2.15)	15.55 (2.42)
Empathic concern	15.21 (2.12)	15.74 (1.52)	15.47 (1.84)
Personal distress	8.06 (2.18)	10.61 (1.94)	9.34 (2.39)

Standard deviations appear in parentheses next to means.

Media consumption

Table 2 shows the number of novels read and cinema movies seen as well as the total number of hours spent watching television and playing video games over the year up to data collection. Pearson correlations were calculated between media consumption and SPF scale scores of each participant. Assuming that increased trait identification would be positively associated with novel reading and movie viewing, the analyses for media consumption were conducted one-tailed and tested for significance at $P < 0.05$. There was a significant correlation between reading novels and fantasy [$r(38) = 0.32$, $P = 0.03$], between movie going and empathic concern [$r(38) = 0.32$, $P = 0.026$], between television viewing and personal distress [$r(38) = 0.29$, $P = 0.037$], and between video gaming and perspective taking [$r(38) = 0.29$, $P = 0.041$]. As an additional analysis, we formed composite values for each participant's media consumption (novel reading, movies, television and video gaming) on the basis of unit-weighted z -scores. This revealed a positive relationship between media consumption and empathic concern [$r(38) = 0.32$, $P = 0.027$] and personal distress [$r(38) = 0.29$, $P = 0.039$].

Identification and CT

The results are reported in Table 3. After controlling for age, gender, intracranial volume and the scores of the other scales (perspective taking, empathic concern, personal distress), the analyses showed a significantly negative correlation between identification and CT (i.e. decreased CT with greater identification) in two clusters in the left dMPFC ($x = -7$, $y = 51$, $z = 19$; $x = -6$, $y = 32$, $z = 41$) (Figure 1A) and a significantly positive correlation in two clusters in the right AI ($x = 39$, $y = -5$, $z = -8$; $x = 47$, $y = -18$, $z = 0$). (See the Supplementary Information S4 for scatter plots showing the distribution of fantasy scores vs the anatomical value at each peak of interest.)

For the additional regions that we explored, analyses showed a significant positive correlation between identification and the left pars opercularis of the IFG (BA 47) ($x = -50$, $y = 13$, $z = 1$) but none of the other regions. Correcting for multiple comparisons in the whole-brain analysis produced no significant correlations between identification and the morphometric measure of CT.

Identification and hippocampal volume

After controlling for brain size, gender, age and the other SPF scales, there was a significant positive relationship between the fantasy scores and the volume of the left hippocampus [$r(31) = 0.48$, $P = 0.009$] as well as left [$r(31) = 0.48$, $P = 0.005$] and right [$r(31) = 0.46$, $P = 0.007$] posterior hippocampus subfields. These correlations reflect strong effects sizes. (See the Supplementary Information S4 for scatter plots.)

Identification and gray matter volume

As shown in Table 3, after controlling for brain size, gender, age and the other SPF scales, the analyses showed a significant positive relationship between the fantasy scores and grey matter density of the ROI

Table 2 Correlations between the scores of each SPF scale and media consumption

Media consumption	Male participants	Female participants	All participants
Books/year	6.47 (7.01)	8.08 (7.74)	7.24 (7.32)
Cinema (movies/year)	5.84 (4.89)	6.07 (5.17)	5.92 (4.97)
TV (hours/week)	6.81 (5.79)	6.08 (5.58)	6.44 (5.62)
Videogames (hours/week)	1.86 (3.96)	2.37 (2.99)	2.12 (3.46)

Standard deviations appear in parentheses next to means.

Table 3 Significant association between CT, trait identification and reading novels

Anatomical location	L/R	Cluster size (mm ²)	Number of vertices	MNI			Max. probability P	Max. correlation r
				x	y	z		
Negative correlations between fantasy scores and CT								
Postcentral gyrus	L	210	421	-34	-33	55	0.000007	-0.68
Precuneus	L	84	189	-7	-47	57	0.0002	-0.58
dMPFC ^a	L	159	180	-8	53	19	0.0003	-0.57
Intraparietal sulcus	L	121	296	-36	-46	36	0.0005	-0.55
dMPFC ^a	L	87	118	-6	32	41	0.001	-0.52
Precentral gyrus	L	102	224	-32	-20	57	0.001	-0.52
Cuneus	R	114	109	5	-84	17	0.001	-0.53
Calcarine sulcus	R	82	81	12	-73	19	0.002	-0.50
Collateral sulcus	R	128	182	43	-38	-15	0.002	-0.48
Positive correlations between fantasy scores and CT								
Pars opercularis	L	114	240	-50	13	1	0.0002	0.58
Precentral sulcus	L	111	221	-55	6	13	0.002	0.49
Insula ^a	R	186	399	39	-5	-8	0.0006	0.54
Insula ^a	R	97	223	47	-18	0	0.001	0.52
Negative correlation between books reading and CT								
DLPFC	L	1086	1364	-34	47	14	0.00008	-0.61
DLPFC	L	89.6	141	-45	32	21	0.002	-0.49

^aA priori defined ROIs; L, left hemisphere; R, right hemisphere; Max: positive value or negative = positive or negative correlation between CT and fantasy score, respectively. Coordinates in MNI space and P -values for peaks in each cluster (statistical parametric maps of the SBM with threshold at $P < 0.01$ uncorrected for multiple comparisons and a cluster extent threshold of $k = 75$ vertices).

in the left DLPFC as defined according to Baumgartner *et al.*'s (2008) study of presence ($x = -46$, $y = 9$, $z = 30$). (See the Supplementary Information S4 for scatter plots.) The ROI defined on the basis of Banissy *et al.* (2012) was not significant.

Media consumption, gray matter volume and CT

After controlling for brain size, gender and age, the analyses showed a significant negative relationship between the composite measure for media consumption and gray matter density in a cluster in the right and left DLPFC ($x = 28$, $y = 54$, $z = 24$; $x = -20$, $y = 56$, $z = 3$) (Table 3). The cluster in the right DLPFC extended to include the cluster reported by Banissy *et al.* (2012) as associated with their fantasy scores. The significant negative relationship between the composite measure for media consumption and gray matter density using the ROI in the right DLPFC defined on the basis of Banissy *et al.*'s study (2012) ($x = 42$, $y = 42$, $z = 30$) is also reported in Table 3. After applying the same controls, CT was negatively associated with reading novels in two clusters in the left DLPFC (Table 3) ($x = -34$, $y = 47$, $z = 13$; $x = -45$, $y = 32$, $z = 21$). The larger of these clusters ($x = -34$, $y = 47$, $z = 13$) includes the region reported in the preceding section of an association between identification and gray matter volume as well as the region defined on the basis Baumgartner *et al.*'s (2008) study of presence.

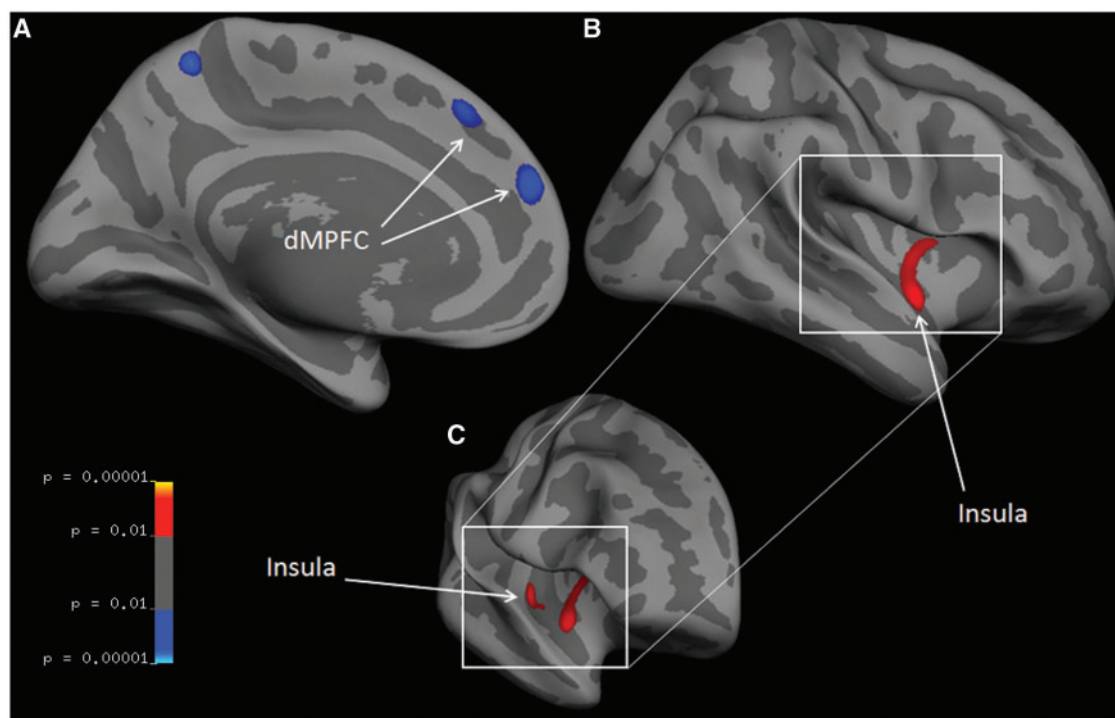


Fig. 1 Statistical parametric maps of the SBM. Significant associations between CT and trait identification in left dMPFC (A) and right insula (B, C). The colour bar signifies the error probability of each cluster's local maxima as reported in Table 3. Red indicates a positive and blue a negative association between CT and identification.

DISCUSSION

Cognitive processes associated with mental imagery, TOM, empathy and self-other merging are thought to contribute to the experience of identification. The hypothesis was tested that variation in the structural morphology of a number of brain regions known to be functionally relevant for these domains is associated with self report-based scores indicating a dispositional tendency to identify with fictive characters. Following Kaufman and Libby (2012), we considered self-other merging in terms of brain regions known to be functionally associated with self-other processing. The data showed that trait identification is associated with the volume of the left hippocampus, with CT in the left dMPFC and the right AI, and with gray matter volume in the left and right DLPFC. The cluster in the left DLPFC was the same as that identified on the basis of functional data by Baumgartner et al. (2008) as pivotally involved in modulating the immersive experience of presence, but the finding of Banissy et al. (2012) could not be replicated. The aim of this study was to find evidence to support the general concept that the proposed regions are relevant for trait identification and to draw on this as a basis for further research into their functional contribution to identification. In the following, the potential contribution of these regions is discussed in terms of the components of identification.

Mental constructive imagery and memory processes are considered important for forming a coherent understanding of a character and its experiences (Polichak and Gerrig, 2002). The hippocampus is likely to play a role in this in that it is critical for the construction of simple and complex imaginary scenarios (see the 'scene construction hypothesis'; Hassabis and Maguire, 2009). It contributes to this construction process by flexibly binding together the elements of an event or scene into a coherent simulation (e.g. Addis and Schacter, 2008) for which it can use information from non-autobiographical fictive sources (Hassabis et al., 2007) and from autobiographical (episodic) memory (see the 'constructive episodic simulation hypothesis'; Schacter and Addis, 2007). Specifically, the initial generation of imaginary episodic

simulations and their elaboration with further detail from memory is known to involve the left hippocampus, as identified in this study, with processing of more detail increasing hippocampal activation (Addis et al., 2007). The lateralization to the left hippocampus likely reflects its involvement in narrative memory (e.g. Frisk and Milner, 1990). This involvement is suggested however to relate to more general aspects of episodic memory (Maguire et al., 1998; Gron et al., 2000; Burgess et al., 2001). The contribution of the left hippocampus might be associated with recall of the spatial context and the reconstruction of the scene of the event (see Hassabis and Maguire, 2009) to facilitate activation and integration of relevant episodic memories in the representation of the mental scenario (Burgess et al., 2001). The latter study suggests however that spatial-context-dependent episodic processing might especially apply when the context of the event includes a person (or character) and not just a place (see Schacter and Addis, 2007). Hippocampal involvement was not found in a study of narrative comprehension (Beeman et al., 2000), but Mar (2004) suggests that this might reflect the use of short and simple narratives in that study. This suggestion corresponds with the finding of increasing hippocampal activation as the demands on elaboration increase (Addis et al., 2007).

Retrieval of episodic and semantic knowledge augments the perception of oneself as (spatially) transposed into the fictive world of a narrative (Braun and Cupchik, 2001; Green et al., 2004). This reflects the idea of spatial-context-dependent episodic processing of identification and personal involvement in the story (Oatley, 1999b). The subjective experience of transportation in narrative is specifically associated with our measure of identification (Hall and Bracken, 2011). The transportation metaphor reflects the idea of an imaginary shift in the effective reference point of perception and experience from the immediate environment of a person to a point in the fictive world (e.g. Lombard and Ditton, 1997) as if the person was spatially present in that world (for a review of presence, see e.g. Jancke et al., 2009). Hippocampal activation is associated with processing one's location in

Table 4 Significant association between trait identification, media consumption and gray matter volume

Anatomical location	L/R	Number of voxels	MNI			<i>T</i>	Degrees of freedom	<i>P</i> _{FWE}	Max. correlation <i>r</i>
			<i>x</i>	<i>y</i>	<i>z</i>				
Positive correlation between fantasy scores and grey matter volume									
DLPFC	L	195	-46	9	30	4.28	30	0.007	0.62
DLPFC			-42	17	31	3.98		0.014	0.59
DLPFC			-39	6	34	3.95		0.014	0.58
Negative correlation between mean z-composite score and gray matter volume									
DLPFC	L	281	-20	56	3	-5.07	34	<0.0001	-0.66
DLPFC			-25	57	10	-4.10		0.0001	-0.58
DLPFC	R	376	28	54	24	-5.61	34	<0.0001	-0.69
DLPFC			34	47	25	-3.45		0.0008	-0.51
DLPFC ^a	R	100	42	42	30	-4.13	34	0.0001	-0.58
DLPFC			36	45	25	-3.57		0.0006	-0.52

L, left hemisphere; misphere; *P*_{FWE} < 0.05. Coordinates in MNI space and *P*-values based on small volume correction with a radius of 10 mm centred on the local maxima after passing a whole-brain uncorrected threshold of *P* < 0.001 combined with a FWE correction *P* < 0.05. ^aAnalysis based on coordinates of Banissy *et al.* (2012).

a mentally visualized scene, especially when this is visualized more vividly (Bird *et al.*, 2010), and with reports of self-projection (see the 'self-projection hypothesis'; Buckner and Carroll, 2007), that is, the perception of oneself as if one were actually in the imaginary scenario (Andrews-Hanna *et al.*, 2010). The imaginary location within the context of the scenario and the visual perspective from that location might guide the very selection of information to be retrieved from memory and integrated in the constructed scenario. The 'temporo-parietal model of spatial memory and imagery' (Byrne *et al.*, 2007) suggests that this is the case and that such a process depends specifically on the hippocampus: The hippocampus retrieves the (allocentric) information that corresponds with an individual's perceived or imagined (egocentric) viewpoint from a particular location within a scenario (see e.g. the 'translation hypothesis' for the translation between allocentric and egocentric representations; Burgess *et al.*, 2001; Byrne *et al.*, 2007). Based on the preceding considerations, the hippocampus might facilitate identification by supporting the imaginary construction and updating of a scenario or situation model of the fictive world and by enhancing the content of this model with autobiographical and semantic knowledge relating to the character. What information is specifically retrieved will depend in part on the imaginary vantage point adopted within a given scenario. In identification, this vantage point is defined by the perceived or imagined location and perspective of the character. Retrieved knowledge is thought to increase the perceived realism and sense of personal relatedness of real and fictive characters in an imagined scenario (Abraham and von Cramon, 2009), and this effect might similarly apply when adopting a character's particular perspective. Given our findings, it is possible that enhanced recruitment of the hippocampus in these processes is positively associated with a sense of feeling transposed into or present in the happenings of a narrative and of a fictive character.

Identification was associated with reduced CT in the left dMPFC. Activation in this region is reported during processing of narrative (e.g. Ferstl *et al.*, 2005; Xu *et al.*, 2005; Virtue *et al.*, 2006; Mason *et al.*, 2009). Xu *et al.* suggest that in the context of narrative comprehension the dMPFC facilitates processing of representations about self in relation to the environment. Consistent with this, the dMPFC (and in fact the same specific cluster as in this study) is preferentially modulated as a function of self-referential processing about one's perceived present situation or mental state (Andrews-Hanna *et al.*, 2010). The MPFC and especially dMPFC are thought also to preferentially contribute to

self-referenced processing of imagined perspectives (Buckner, 2008). Individuals can flexibly shift their mental perspective away from the immediate present and project (or transport) themselves into imaginary simulations of real and fictive scenarios (for the 'self-projection hypothesis', see Buckner and Carroll, 2007). It is conceivable that processes associated with the dMPFC contribute to modulating the relation between aspects of the self and the perceived or imagined perspective of the immediate and fictive world. Given the potential role of the hippocampus in this study, it should be noted that the nature of any interplay in self-projection between the dMPFC and hippocampus is not clear (Buckner, 2008), though the dMPFC (and the region within it reported in this study) does appear to be associated with the construction system network (Hassabis and Maguire, 2009).

The dMPFC is thought also to be involved in the coordination and contrasting of cognitive representations of self and other in various tasks (Decety and Sommerville, 2003). In common with the findings that identification involves processing (and the perception of adopting) a character's role, traits, beliefs, goals and emotions (Davis, 1996; Oatley and Gholamain, 1997; Cupchik *et al.*, 1998; Cohen, 2001; Tal-Or and Cohen, 2010; Mar *et al.*, 2011), the dMPFC is consistently reported in tasks that entail processing of attributes, affective and mental states, and experiences relating to oneself, to others, to both oneself and others, and in other monitoring such as when a character's situation in narrative changes (e.g. Gusnard *et al.*, 2001; Fossati *et al.*, 2003; Northoff and Bermpohl, 2004; Guroglu *et al.*, 2008; Speer *et al.*, 2009; Moran *et al.*, 2011). Mason and Just (2009) propose the engagement during narrative of a 'protagonist perspective network' based chiefly on the dMPFC and TPJ, the former monitoring the progress of a character during the entire narrative (protagonist monitoring). The finding that trait identification is associated with the CT in the left dMPFC might reflect a role for this region in coordinating and contrasting the representations about aspects of the self in relation to aspects of the immediate and fictive world real of a character and to aspects of that character. Assuming that the direction of the structure-identification relationship reflects a positive functional-identification relationship, a positive relationship between CT and dMPFC might have been expected. On the other hand, if the relationship between self and other is altered during identification compared with perspective taking in the way that Kaufman and Libby (2012) propose (i.e. reduced activation of representations of the self and maintenance of representations and processing of other) it is possible that this alteration is reflected in attenuated demands on cognitive resources required to process, coordinate and represent self and other during identification compared with tasks that require explicit perspective taking and representation of self and other. We note however that our data show no association between perspective taking and dMPFC (with or without controlling for the other IRI scales). It remains unclear without further investigation whether our finding in the dMPFC is actually related to the idea of self-other merging. This cannot be ascertained with our measure of identification.

The happenings of the fictive character include the characters' affective experiences. The ability to share and experience the character's affective state enhances identification (e.g. Zillmann, 1991; Tal-Or and Cohen, 2010; see also, Green *et al.*, 2004; Appel and Richter, 2010; Mar and Oatley, 2008). Affect sharing means that the perceived affective state of another is automatically translated onto representations of our own states and vicarious experiences (e.g. Eisenberg, 2000; Decety and Jackson, 2004). We identified two clusters in the right mid-to-anterior insula that were positively associated in CT with identification. Lowering the threshold showed that this cluster extends anteriorly into the AI. The insular cortex has been referred to as the 'interoceptive cortex', given its involvement in representing subjective feeling and internal bodily states (e.g. Damasio, 1994; Craig, 2002; Critchley,

2005). The AI has often been identified in association with sharing various emotions of another person's perceived affect (Fan *et al.*, 2011), and activity in the right mid- and anterior insula is associated with measures of arousal (heart rate and galvanic skin responses) (e.g. Critchley *et al.*, 2002; Lutz *et al.*, 2009). It is conceivable that the positive association between identification and the right insula reflects the insula's increased involvement in the affective component of trait identification by representing and processing the perceived subjective feeling and internal bodily states of a character. Presumably, those reporting lower trait identification might be less likely to share affect with fictive characters, assuming that this is the direction of the structure–trait relationship. Our exploration of further regions revealed a role for the left IFG in trait identification. Our IFG converges on the cluster in Fan *et al.*'s (2011) meta-analysis that they report as specifically associated with the affective–perceptual form of empathy (i.e. affect sharing) for a range of affective states. The adjacent regions of the left IFG are the areas of Broca and premotor cortex. These have been associated together with the IFG in the observation, initiation and comprehension of action and the suggested supporting role for these functions of the system of motor mirror neurons (e.g. Rizzolatti *et al.*, 2001; Rizzolatti and Craighero, 2004) that some have suggested facilitate affect sharing by enabling automatic simulation of other's affective behaviour (Decety and Jackson, 2004; Gallese *et al.*, 2004).

Banissy *et al.* (2012) reported a positive association between their fantasy scores and gray matter volume in the right DLPFC. We were unable to replicate their finding, but our composite measure of actual media consumption was associated with that same right DLPFC cluster. Interestingly, our behavioural data reveal a positive relationship between media consumption and the traits empathic concern and personal distress, and Banissy *et al.* constrained their ROI analysis to this region of the DLPFC on the basis of Lamm *et al.*'s (2011) meta-analysis of directly experienced pain and empathy for pain. Taken together, these results suggest a role for this region of the DLPFC in identification, empathic concern and personal distress but that the relationship between these and the DLPFC might be influenced by effects of actual media exposure.

A relationship was found in this study between trait identification and the gray matter volume of left DLPFC in a region defined according to a study of the functional correlates of 'presence' (Baumgartner *et al.*, 2008). Presence refers to the subjective perception of oneself as situated in and responsive to events in a virtual environment while unaware of the real surroundings and the immersive virtual reality (VR) technology that delivers the virtual input to the senses (Jancke *et al.*, 2009). Using 'psycho-physiological interaction' analysis (Friston *et al.*, 1997), the left DLPFC was found to be critical in modulating activity within brain regions of the dorsal attention system (e.g. Fox *et al.*, 2006) and the brain's default system (Buckner *et al.*, 2008). The DLPFC is involved in regulating the balance between these networks during exposure to VR (Beeli *et al.*, 2008) and it is possible that it plays a similar role during experience of other media and identification. Importantly, Baumgartner *et al.* found also that self-reports of presence experience were specifically associated with the same region of the DLPFC and its modulatory role.

It should be noted that Baumgartner *et al.*'s study presented a sensory-rich visual roller coaster display, the aim of the study being to engage participants in a perceptual experience that would provoke activation of cognitive processes conducive to presence. But individuals can feel absorbed by fictive events and characters in response to sensory-poor media technologies such as media text (Biocca, 2002). We collected data on media consumption because short- and long-term learning and behaviour are known to induce change in brain morphology (e.g. Draganski *et al.*, 2004) and because our measure of trait identification is based in items relating to subjective experience

during examples of media exposure. These data show that trait identification is positively associated with reading novels. Our analyses show also that novel reading is negatively associated with CT in a sizable cluster of the left DLPFC that includes the same cluster found for the positive association between gray matter volume and identification. Clearly, these relationships are not straight forward, especially as we found no association between the DLPFC and movie going that might have been expected given the association between DLPFC and presence and reading of narratives.

Trait identification reflects a tendency to respond consistently across situations and time in thought, feeling and behaviour to fictive characters. The approach in this study of using functional data to guide the selection of likely brain regions associated with trait identification assumes that there is to a greater or lesser extent a meaningful association between the variance in trait identification, in the brain functions that mediate the state experience of identification, and in the structural morphology of regions that house these functions. It is sometimes assumed that measures of cortical morphology are positively associated with trait behaviour (e.g. Gardini *et al.*, 2009; deYoung *et al.*, 2010). This 'bigger-is-more' assumption is reflected for example in findings of training-related enhancement in performance and associated increases in brain grey matter (e.g. Jancke, 2009) though a 'less is more' relationship for trait behaviour has also been discussed (e.g. Banissy *et al.*, 2012). A clear interpretation of the direction of the structure–function relationship of brain regions identified in this study requires further investigation of how differences in the microstructure of these regions, such as the number of neurons, relate to individual differences in function and behaviour. Given that mental imagery, TOM, empathy and, presumably, merging are mediated by in part tightly correlated functional networks (e.g. Buckner *et al.*, 2008), this relationship is likely to be complex.

In summary, this study shows that there is a relationship between variation in cortical and subcortical morphology of specific brain regions and individual variation in trait identification. The specific relationship between these regions and the individual components of identification awaits investigation. Merging was considered in terms of self-other processing, but we note that the underlying mechanisms and differences in processing the self-other distinction in perspective taking compared with merging (Kaufman and Libby, 2012) are not clear and need to be investigated further. Given our focus on the structural underpinnings of trait identification, we used no measures of actual identification experience with fictive characters. Further work is thus needed to ascertain how the regions identified in this study are functionally associated with the state experience of identification. We did not consider the potential impact of trait differences in imagery vividness, imaginativeness or fantasy proneness on identification-related variation in cortical and subcortical morphology, the potential contribution of which is worth considering in future work. The SPF has no items relating to experience with virtual reality, and no participants with any background of intensive exposure to media characters in virtual reality such as those in video games were recruited. The interactive nature of video gaming and the ability of the user to actively influence mediated characters and events may impact differently on cortical morphology and identification than our results show for participants without any such experience.

SUPPLEMENTARY DATA

Supplementary data are available at SCAN online.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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