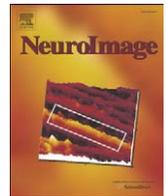




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Neural networks involved in self-judgement in young and elderly adults

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ABSTRACT

Recent studies have shown that both young and elderly subjects activate the ventromedial prefrontal cortex (VMPFC) when they make self-referential judgements. However, the VMPFC might interact with different brain regions during self-referencing in the two groups. In this study, based on data from Ruby et al. (2009), we have explored this issue using psychophysiological interaction analyses. Young and elderly participants had to judge adjectives describing personality traits in reference to the self versus a close friend or relative (the other), taking either a first-person or a third-person perspective. The physiological factor was the VMPFC activity observed in all participants during self-judgement, and the psychological factor was the self versus other referential process. The main effect of first-person perspective in both groups revealed that the VMPFC was co-activated with the left parahippocampal gyrus and the precuneus for self versus other judgments. The main effect of age showed a stronger correlation between activity in the VMPFC and the lingual gyrus in young compared to elderly subjects. Finally, in the interaction, the VMPFC was specifically co-activated with the orbitofrontal gyrus and the precentral gyrus when elderly subjects took a first-person perspective for self-judgements. No significant result was observed for the interaction in young subjects. These findings show that, although the VMPFC is engaged by both young and older adults when making self-referential judgements, this brain structure interacts differently with other brain regions as a function of age and perspective. These differences might reflect a tendency by older people to engage in more emotional/social processing than younger adults when making self-referential judgements with a first-person perspective.

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Introduction

Functional neuroimaging and neuropsychological studies have recently revealed the importance of cortical midline structures for processing information related to the self. In particular, activation of the ventromedial prefrontal cortex (VMPFC) has been repeatedly observed when subjects think about themselves (Northoff and Bermpohl, 2004; Northoff et al., 2006) and specifically when they make judgements regarding their own personality traits (D'Argembeau et al., 2007; Gutchess et al., 2007; Heatherton et al., 2006; Ruby et al., 2009; Kelley et al., 2002; Johnson et al., 2002). In addition, lesion studies suggest that damage to the VMPFC leads to deficits in self-awareness (Stuss et al., 2001a,b).

The concept of self is complex. Self underlies the identity of an individual and contains all the information which describes the individual (goal, aspiration, memories, thought, emotion, personality traits, and attitude; Duval et al., 2009). During his life, the individual tends to stability and coherence. Memories of specific experiences are encoded to serve the construction and the maintenance of the self

(Conway, 2005). Moreover, the self is also constituted from semantic knowledge about own psychological characteristics (Klein et al., 2002; D'Argembeau et al., 2008). Consequently, self, episodic/semantic memory and autobiographical memory are intimately tied and work together to promote stability and coherence (Conway, 2005). However, according to the evolution of goal, social context and status of the individual in the society during his or her life span, the self changes across time. Indeed, modifications in personality traits have been reported in aging (Jones et al., 2003; Caprara et al., 2003). One may wonder if that evolution of self is accompanied by modifications of brain processes involved in performing self-judgments across life? Neuroimaging is particularly adapted to answer this question, however, at this time, only two studies have explored the cerebral areas associated with self-referential processing in normal aging. Gutchess et al. (2007) observed that young and older adults engaged the VMPFC to a similar extent when judging personality traits in reference to the self versus another person. The only cerebral differences between the groups in self versus other personality assessment were found in somatosensory and motor-related areas. Ruby et al. (2009) have explored the neural substrate of self-personality assessment from different perspectives. Young and older adults evaluated personality traits in reference to the self versus a close friend or relative. Moreover, they were asked to make those judgements from either their own (first-person) perspective or

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the perspective of their friend or relative (third-person perspective). Behavioural performances revealed preserved abilities of perspective taking on self and other in aging. In keeping with the findings of Gutchess et al. (2007), the VMPFC and anterior cingulate cortex (ACC) were activated by both young and elderly subjects during self versus other personality judgements, regardless of the perspective taken (first- or third-person). Differences between the two groups were noted in the dorsomedial prefrontal cortex (DMPFC) and the precuneus, which showed greater activation in young than in older adults. There were also age-related differences in the neural correlates of perspective taking, with the lingual gyrus and the posterior part of the dorsomedial prefrontal cortex being more activated in young than in elderly subjects during third-person (versus first-person) perspective taking.

Overall, these findings show that both young and older adults recruit the VMPFC when making self-referential judgements and that there are relatively few differences between the two groups regarding the other brain regions activated. However, it remains possible that the VMPFC co-activates differentially in young and older adults with brain areas associated to self-referential processes. Specifically, the VMPFC might interact with distinct brain regions in young and older adults due to possible age-related differences in the cognitive and/or emotional processes that contribute to self-referential judgements (Levine et al., 2002; Mickley and Kensinger, 2009). Consequently, the aim of this study was to investigate this issue by performing psychophysiological interaction (PPI) analyses of Ruby et al.'s (2009) data. The interest of PPI analyses is to provide supplementary information to that previously reported using between groups and conditions analyses. In PPI analyses, two factors are implemented: a physiological factor, which expresses the cerebral activity in a particular brain area (specified as seed area), and a psychological factor, which refers to a specific contrast of experimental conditions. Results of PPI analyses show the set of cerebral areas which are co-activated with the seed area in a specific contrast of the psychological factor (Friston et al., 1997). Concretely, in our study, this analysis allowed to unravel networks of cerebral regions that were functionally related to (i.e., co-activated with) the VMPFC (physiological factor), when young and elderly subjects made self (versus other) referential assessments (psychological factor). Our objective was also to look for possible differences between the first- and third-person perspectives, and for interaction between age and perspective taking in brain regions co-activated with the VMPFC during self-judgements.

Methods

Participants

Data were acquired from a group of 17 right-handed elderly subjects (13 women; mean age 67 ± 4 years) and their relatives (10 spouses, 4 children and 3 friends) as well as from a group of 17 young subjects (11 women, mean age 23 ± 3 years) and their best friends. Elderly participants were recruited with posters in a seniors' club in Liège. Young participants were recruited among the student population of the University of Liège. None of the participants had any relevant medical history or used any centrally acting medication. All the participants gave written informed consent prior to their inclusion in the study. The study was approved by the Ethic Committee of the Faculty of Medicine of the University of Liège.

Task

Subjects participated in the study with someone who knew their personality well (a close relative or friend). All subjects were asked to make personality assessments concerning themselves or their relative/friend, taking their own or their relative/friend's perspective. Hence, the perspective taken by the participants (first- or third-person perspective) and the target person (self or other) were manipulated according to a 2×2 factorial design, resulting in four conditions: taking a first-

person perspective when judging one's own personality (1P_Self), taking a first-person perspective when judging a relative/friend's personality (1P_Other), taking a third-person perspective when judging one's own personality (3P_Self), and taking a third-person perspective when judging a relative/friend's personality (3P_Other). In the first-person perspective-taking conditions, the subjects evaluated to what extent a series of adjectives described their own personality (1P_Self) or the personality of their close relative/friend (1P_Other). Concretely, the subjects answered questions such as 'Am I sociable?' (1P_Self) and 'Is my relative/friend sociable?' (1P_Other). In the third-person perspective-taking conditions, participants were asked to 'put themselves in the shoes of their friend or relative' to estimate how this person would assess the adjectives. The 3P_Self condition required participants to evaluate the extent to which the adjectives described the way their friend or relative perceived them in terms of personality traits (e.g., 'According to my relative/friend, am I sociable?'). In the 3P_Other condition, participants evaluated the extent to which the adjectives described how their friend or relative perceived their own personality traits (e.g., 'According to my relative/friend, is she sociable?').

The same set of 40 adjectives was presented in all four conditions. The adjectives were selected from the study of Klein et al. (1996) and translated into French. The adjectives had characteristics close to the norm mean values reported by Kirby and Gardner (1972) on the dimensions of familiarity, imagery and social desirability.

The four conditions were presented in a single functional MRI session, according to a block design. Ten blocks were presented per condition (1P_Self, 1P_Other, 3P_Self, and 3P_Other). Each block consisted in the presentation of 4 adjectives for 5 s each. Three seconds before the start of each block, a brief instruction appeared on the screen to inform the participants about the kind of judgement required for the subsequent block. The instruction remained on the screen throughout the presentation of the block. For each condition, the subjects had to judge the relevance of the adjective by choosing one of the four possible responses (1 = not at all, 2 = a little, 3 = quite well, and 4 = completely).

While subjects (young and elderly) performed the task during an fMRI session, relatives and friends answered the task through paper questionnaires during an interview with experimenter. Participation of relatives and friends allowed to assess if the ability of perspective taking (in first- and third-person) on self and other is preserved. Congruency scores were calculated by comparing subject's answers to their relative's answers (which were considered as reference answers). A more detailed description of the procedure is available in Ruby et al. (2009).

MRI acquisition

Data were acquired on a 3 T scanner (Siemens, Allegra, Erlangen, Germany) using a T2* sensitive gradient echo EPI sequence (TR = 2130 ms, TE = 40 ms, FA 90°, matrix size $64 \times 64 \times 32$, voxel size $3.4 \text{ mm} \times 3.4 \text{ mm} \times 3.4 \text{ mm}$). Thirty-two 3-mm thick transverse slices (FOV $22 \text{ cm} \times 22 \text{ cm}$) were acquired, with a distance factor of 30%, covering the whole brain. Structural images were obtained using a T1-weighted 3D MP-RAGE sequence (TR = 1960 ms, TE = 4.4 ms, FOV $23 \text{ cm} \times 23 \text{ cm}$, matrix size $256 \times 256 \times 176$, voxel size $0.9 \text{ mm} \times 0.9 \text{ mm} \times 0.9 \text{ mm}$). In each session, between 629 and 650 functional volumes were obtained. The first three volumes were discarded to account for T1 saturation. Head movements were minimized by retaining the subject's head using a vacuum cushion. Stimuli were displayed on a screen positioned at the rear of the scanner, which the subject could comfortably see through a mirror mounted on the standard head coil.

Functional data analyses

Data were analysed using SPM8 software (SPM8, Wellcome Department of Imaging Neuroscience, <http://www.fil.ion.ucl.ac.uk/spm>), implemented in MATLAB (Mathworks Inc., Sherborn, MA).

For each subject, functional scans were realigned using iterative rigid body transformations that minimize the residual sum of square between the first and subsequent images. Functional scans were normalized to the MNI EPI template (voxel size, $2 \times 2 \times 2$ mm) and spatially smoothed with a Gaussian kernel with full width at half-maximum (FWHM) of 8 mm.

Data were processed using two-step analysis, taking into account the intra-individual and inter-individual variance respectively. For each participant, brain responses were modelled at each voxel, using a general linear model with events as regressors. Events were divided according to the target of the judgment (self or other) and the perspective taken (first- or third-person perspective). Event durations corresponded to the presentation of the adjective until the subject's response, with a maximum duration of 5 s. Event types were modelled through convolution with a canonical hemodynamic response function. The design matrix also included the realignment parameters to account for any residual movement-related effect. A high-pass filter was implemented using a cut-off period of 128 s in order to remove low-frequency drifts from the time series. Serial autocorrelations were estimated with a restricted maximum likelihood algorithm with an autoregressive model of order 1 (+ white noise). The comparison of judgement target [self versus other: (1P_Self + 3P_Self) – (1P_Other + 3P_Other)] was the contrast of interest to select our VMPFC seed region given that the seed area had to be activated specifically when the target of judgment was the self (and not the other), whatever the perspective taken to perform the judgment.

The resulting set of voxel values constituted a map of t statistics [SPM{T}]. The contrast images from each participant were further smoothed (6-mm FWHM Gaussian kernel) to accommodate inter-individual variability in brain anatomy (see Ruby et al., 2009).

Individual contrast images were then entered into a second-level analysis, corresponding to a random effect model, in order to account for inter-subject variance in the contrast of interest [(1P_Self + 3P_Self) – (1P_Other + 3P_Other)]. No significant activation was observed with a threshold $p < 0.05$ corrected for multiple comparisons. Consequently the resulting SPM{T} maps were thresholded at $P < 0.001$ and statistical inferences were performed at the voxel level at $P < 0.05$ corrected for a small volume, defined as a 10-mm radius sphere around a published coordinates of VMPFC [–4 54 2], previously associated to self reference judgement in young subjects (D'Argembeau et al., 2005).

Using the same published coordinate as a-priori hypothesis in a block-analysis, Ruby et al. (2009) reported activation of the VMPFC at the coordinates [–4 52 12] and [–6 50 8] in self versus other judgment for young and elderly people respectively. However, in our event-related analysis, this contrast showed slightly different peaks of activity in the VMPFC, respectively located at [–2 52 12] for young subjects and at [–14 44 6] for elderly subjects.

The coordinate of the seed area introduced as physiological factor in PPI analyses must be identical for all subjects (young and elderly). Consequently, a second random effect model, where all subjects were included as being part of a single group was performed to select the coordinate corresponding to this criteria. This analysis confirmed that all subjects activated both VMPFC regions for self-judgments. More precisely, Fig. 1A displaying the parameter estimates related to the contrast of interest in the first area [–2 52 12] showed that both young and elderly subjects had a similar profile when the target of the judgment was self. A similar display for the second area [–14 44 6] showed that activity was also higher for self than for other judgment (Fig. 1B). However, elderly subjects appeared to have higher activation in this area than young subjects. Accordingly, the VMPFC at coordinate [–2 52 12] was selected as the seed area for further PPI analyses since it was similarly recruited by young and older subjects.

Functional connectivity was subsequently assessed by psychophysiological interactions. These analyses attempted to determine whether the target of judgement (self versus other) modulated the correlations between activity in the VMPFC [–2 52 12] and distant

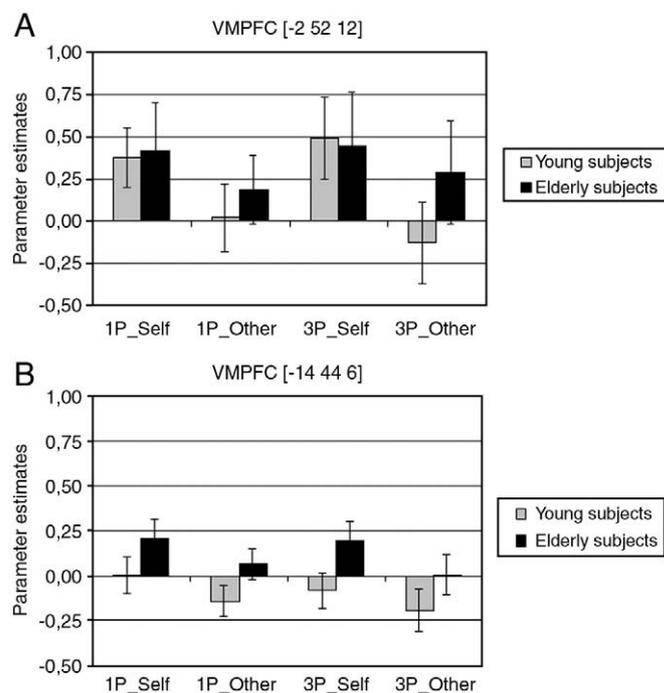


Fig. 1. Parameter estimates in VMPFC located (A) in [–2 52 12] and (B) in [–14 44 6] for each kind of events (1P_Self, 1P_Other, 3P_Self, and 3P_Other) in each group respectively. Error bars represent standard error. In each area of the VMPFC, the parameter estimates were higher when the target of the judgment was self versus other. In the second area, elderly subjects appeared to have higher activation than young subjects.

brain regions during judgement on personality adjectives. For each subject, the cerebral activity during the task was extracted from the volume of interest (a spherical VOI of 10-mm radius measured from the coordinate of the seed area previously selected) respectively in first and third-person perspective taking. Next a new linear model was then estimated for PPI analyses, separately for first- and third-person perspective taking for each subject. Three regressors were constructed (plus the realignment parameters as covariates of no interest, as in the initial model). One regressor represented the target of the judgement (self versus other). The second was the activity in the reference area (VMPFC). The third represented the interaction of interest between the first (psychological) and second (physiological) regressors. Significant contrasts for this psychophysiological regressor indicated a change in the regression coefficient between any reported brain area and the reference region, as a function of the judgement condition (self versus other). After smoothing (6-mm FWHM Gaussian kernel), these contrast images were entered in a second-level (random effects) analysis to perform intra- and inter-group comparisons. Data for groups (young and elderly subjects) and perspective (first- and third-person perspective taking) were entered in the same design matrix. The main effect of perspective [(P1>P3) and (P3>P1)], the main effect of group [(Y>E) and (E>Y)] and two effects of interaction [(P1E–P1Y)–(P3E–P3Y); (P1Y–P1E)–(P3Y–P3E)] have been performed. The SPM{T} maps were thresholded at $P < 0.001$ at peak level and $P < 0.09$ at cluster level. As a final verification, a similar correlational analysis was performed at the group level where the self condition alone was entered in the design matrix, corroborating the (significant) positive direction of the relationships between the VMPFC and the other brain regions identified in PPI analyses (Lombardo et al., 2009).

Results

Data of Ruby et al. (2009) have been analysed according to an event-related procedure. Results for the main effect of the target

person (self versus other) in elderly subjects showed that, except for the DMPFC, all the areas reported by Ruby et al. (2009), namely the VMPFC, ACC and subgenual cortex were also observed in the present study. No additional area has been observed. Results for young subjects were also similar to those of Ruby et al. (2009) (VMPFC, ACC, DMPFC, superior frontal sulcus, and inferior parietal lobule), except for activation in precuneus that was not found in our analyses.

A summary of the main effects and interactions for the PPI analyses is given in Table 1. All the stereotactic coordinates refer to the MNI space.

The main effect of first-person perspective taking ($P1 > P3$) showed that during self versus other referential judgments, the VMPFC was co-activated with the left parahippocampal gyrus and the precuneus to a greater extent when the judgments were made from the first-person rather than the third-person perspective. No significant result was found for the reverse main effect ($P3 > P1$).

For the main effect of group, we found that the VMPFC was more correlated with activity in lingual gyrus in young compared to elderly subjects. No significant result was found for the reverse main effect (elderly > young).

Finally, two interaction analyses were performed, namely ($P1E - P1Y$)–($P3E - P3Y$) and ($P1Y - P1E$)–($P3Y - P3E$). The first interaction examined the specific effect of the first-person perspective in elderly subjects, whereas the second interaction examined the specific effect of the first-person perspective in young subjects. Preferential co-activations were found between the VMPFC and the medial and left lateral orbitofrontal gyrus in the first interaction (Fig. 2). The right precentral gyrus was also co-activated with the VMPFC in first-person perspective for elderly more than young subjects. No significant result was found for the second interaction.

Discussion

The study first confirmed a similar activation of the VMPFC in elderly and young subjects who made self (compared to other) judgment on personality adjectives, when reanalyzing previous data (Ruby et al., 2009) with SPM8 and events regressors. Secondly, our PPI analysis provided new data compared to previous between group comparisons. It revealed both similarities and differences between

young and elderly healthy subjects when they took a first-person (versus a third-person) perspective to make their judgment, suggesting that the VMPFC does not recruit exactly the same processes to perform self-referential judgments according to age and the perspective taken. As the abilities of perspective taking and self-assessment were preserved with aging (Ruby et al., 2009), the difference observed between the two groups in the network recruited with the VMPFC for self-evaluation cannot be imputed to a deficit in one of these capacities in elderly subjects. Some previous studies explored the VMPFC co-activation with other brain regions in self-judgment in young subjects (Lombardo et al., 2009; Schmitz and Johnson, 2006). However, our results cannot be directly compared to these previous reports because we deliberately contrasted self versus other judgment, and we did not look for commonalities between them (Lombardo et al., 2009), and because we did not use a non referential condition (Schmitz and Johnson, 2006).

Our results showed that when young and elderly subjects made a self-judgment from their own rather than the other person's perspective, the VMPFC activation was more correlated with activity in the left parahippocampal gyrus and the precuneus. These two areas have previously been associated with declarative memory but may play distinct roles. The left parahippocampal gyrus has been associated with the retrieval of specific contextual information ([−24 −33 −15] Kahn et al., 2004; [−33 −40 −17] Yonelinas et al., 2001; [−28 −36 −20] Gardini et al., 2006), whereas the precuneus has been associated with the regeneration of rich contextual associations, with correct source retrieval ([−6 −70 60] Lundstrom et al., 2005), as well as with complex mental imagery, implying re-construction, maintenance and visualisation of complex scenes ([6 −66 60] Hassabis et al., 2007). The left parahippocampal gyrus and the precuneus are also involved in autobiographical memory retrieval (for a meta-analysis, see McDermott et al., 2009; Svoboda et al., 2006). Considering these findings, the current data suggest that the VMPFC may assess different types of self-referential information when making self-judgments from one's own perspective versus the perspective of another person. More specifically, the increased coupling of the VMPFC to the left parahippocampal gyrus and the precuneus may reflect the retrieval of more specific autobiographical details (perhaps especially visual details; Conway, 2003; Conway et al., 2003) and the reinstatement of the information in a congruent visual scene when making self-judgments from a first-person than when making the same judgments from a third-person perspective. This is true for both young and elderly participants.

A co-activation between the VMPFC and lingual gyrus was specific to young subjects when they performed self-judgment. This results suggests that the lingual region reported by Ruby et al. (2009) in the main effect of perspective (third-person > first-person) in young subjects was in fact recruited by the VMPFC both for first-person and third-person perspective taking. This area has been reported in studies exploring autobiographical memory ([−4 −86 0] Levine et al., 2004; [−16 −86 −8] Addis et al., 2007), and Cui et al. (2007) have reported that early visual cortex activity is positively correlated to vividness of mental imagery when subjects visualized themselves or another person accomplishing particular actions (e.g., stair climbing). Although participants were not explicitly requested to retrieve autobiographical memories or to visualize particular scenes in our experiment, it is possible that when young participants assessed their own personality traits, they spontaneously formed visual images of some personal experiences (e.g., visualizing situation when one usually manifests a particular trait) to a greater extent than older adults.

A co-activation of the right precentral gyrus with the VMPFC has been observed in the interaction, when elderly (compared to young) subjects took a first-person (compared to a third-person) perspective. The premotor cortex is not only involved in the production of actions (Wise, 1985) but also in mentally simulating movements in the absence of the actual production of actions (for a review, see Decety and Grèzes, 2006). Notably, a study of perspective taking has shown

Table 1

	vox	x	y	z	Cluster-level P value (uncorrected)	Z-score
<i>Main effect of perspective: P1 > P3</i>						
L parahippocampal gyrus	143	−30	−44	−10	0.090	3.69
Precuneus	147	2	−64	66	0.087	4.12
<i>Main effect of perspective: P3 > P1</i>						
	–	–	–	–	–	–
<i>Main effect of group: Y > E</i>						
Lingual gyrus	782	0	−92	−8	0.001	4.52
<i>Main effect of group: E > Y</i>						
	–	–	–	–	–	–
<i>Effect of interaction: (P1E–P1Y)–(P3E–P3Y)</i>						
Medial orbitofrontal gyrus	670	4	28	−22	0.001	4.08
L orbitofrontal gyrus		−16	44	−22	0.001	4.38
R precentral gyrus	145	46	−24	66	0.089	3.55
<i>Effect of interaction: (P1Y–P1E)–(P3Y–P3E)</i>						
	–	–	–	–	–	–

The stereotactic coordinates refer to the MNI space. L=left hemisphere; R=right hemisphere; vox=number of voxels in cluster. P1 and P3 refer to first- and third-person perspectives. Y=young and E=elderly participants. The SPM(T) maps were thresholded at $P < 0.001$ at peak level and $P < 0.09$ at cluster level.

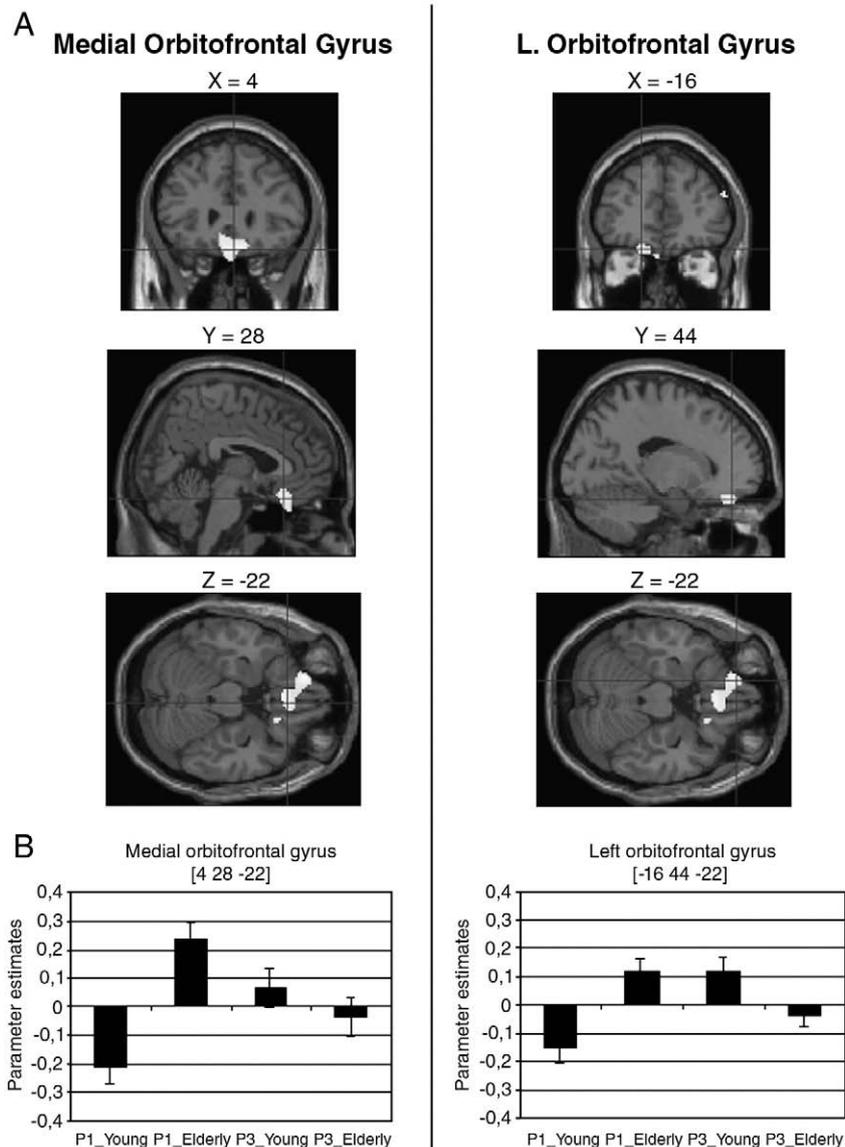


Fig. 2. A. Orbitofrontal activation found in the interaction (P1A–P1J)–(P3A–P3J). Left: medial orbitofrontal activity; and right: left orbitofrontal activity. B. Parameter estimates in left and medial orbitofrontal gyrus according to perspective taking in each group. Left: medial orbitofrontal activity; and right: left orbitofrontal activity. Error bars represent standard error.

that mental simulation of actions in the first-person perspective induced increased activity in the premotor cortex, relative to imagining actions from a third-person perspective, suggesting that this brain region may contribute to distinguishing one's own actions from the actions of others (Ruby and Decety, 2001). In the same vein, Grèzes et al. (2004) reported that premotor area coded for the distinction between self versus other, being active earlier when subjects saw themselves performing an action than when they saw another person performing the same action. Besides the motor domain, a recent study has shown that sensorimotor areas are also involved in higher-level mentalizing tasks, such as judging one's own and others' mental characteristics (Lombardo et al., 2009). The activation of the premotor cortex when thinking about one's own personality traits might reflect the activation of mental representations of actions related to the trait under consideration (e.g., representing actions related to being clumsy). The current findings could reflect a tendency for elderly subjects to rely on such mental representations of actions more than young subjects when evaluating their own personality traits. This hypothesis remains speculative, however, and should be tested more directly in future studies.

Probably the most interesting result of the current study relates to the higher co-activation between the VMPFC and two orbitofrontal regions when elderly subjects assessed their own personality traits from a first-person perspective. Both VMPFC and orbitofrontal regions have been associated with social abilities (Stone et al., 1998). Our first co-activation with the VMPFC concerned the medial orbitofrontal gyrus. This area has been associated with social processes, namely regulation of emotion ([12 24 –24] Ohira et al., 2006; [–2 42 –16] Abe et al., 2007; [–3 36 –12] Kim and Hamann, 2007) and understanding/interpretation of action and intention of other people ([–4 38 –26] Harvey et al., 2007). Our second co-activation with the VMPFC has been found in a slightly more lateralized left orbitofrontal region, that was previously activated for emotional perspective taking ([–24 34 –16] Hynes et al., 2006) and regulation of emotion ([–21 39 –18; –21 48 –15] Kim and Hamann, 2007). This would be consistent with the observation that the left orbitofrontal cortex participates in self-monitoring of social relationships and in the expression of appropriate emotions when judging personal social interactions (Beer et al., 2006). In our experiment, elderly subjects may particularly recruit the medial and left lateral orbitofrontal cortices to

monitor the social/emotional context associated with the evaluation of personality trait adjectives for self-relevance.

Conclusion

The VMPFC is activated in both young and elderly subjects when they perform self-judgements on personality trait adjectives (Gutchess et al., 2007; Ruby et al., 2009). Our PPI analyses demonstrated that the VMPFC is co-activated with not only common but also with different brain regions in elderly and in young subjects during self-evaluation. Co-activation of the parahippocampal gyrus and the precuneus was observed for first-person perspective taking in the two groups, and may be related to the retrieval of autobiographical information and to the reintegration of contextual information related to past personal events. Moreover, young subjects might retrieve visual details to a greater extent than elderly subjects when making self-judgments, as attested by predominant co-activation between the VMPFC and the lingual gyrus to perform their judgments (whatever the perspective). With regard to interaction effects, a first-person perspective taking in older participants seemed to depend on retrieval of low-level sensorimotor information, as attested by coactivity between VMPFC and right precentral gyrus. Importantly, elderly subjects taking a first-person perspective also appeared to base their self-judgement on orbitofrontal regions more than young participants, and that may reflect enhanced involvement of socio-emotional processing in older participants (Carstensen and Lockenhoff, 2003).

Resting on the same set of data as Ruby et al. (2009), the results of PPI analyses were relatively different from those of Ruby et al. (2009). This can be interpreted by the methodology used in each study. Firstly, data have been re-explored with an event-related procedure and secondly PPI analyses explored more than a simple activation in a specific condition, it explored the neuronal network that co-activated with an area sensitive to self-processes (VMPFC), in a condition where subjects thought about themselves (versus other). Results of PPI analyses extend those of Ruby et al. (2009), suggesting that evaluative processes are based on emotional/social processing in elderly subjects.

Acknowledgments

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