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TIME-TRAVELLING AND MIND-TRAVELLING: EXAMINING INDIVIDUAL DIFFERENCES IN SELF-PROJECTION

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SUMMARY

It has recently been suggested that memory and theory of mind may share the characteristic of mentally projecting oneself into another time or place to imagine alternative perspectives. This study examines this possible relationship by investigating individual differences in performance on a reality monitoring task and two mentalising tasks: the faux pas task and the reading the mind in the eyes test. Consistent with recent functional neuroimaging studies that have observed activity during reality monitoring tasks in the same region of prefrontal cortex that was activated in previous mentalising studies, a significant positive correlation in performance was observed between memory for agency and faux-pas recognition. No correlation between memory and performance on the reading the mind in the eyes test was observed. The significance of these findings is discussed with respect to the suggestion that memory and theory of mind rely on a common set of processes.

Key words: *self projection - theory of mind - reality monitoring*

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INTRODUCTION

'Mental time-travel' was described by Tulving (1985) as a cardinal feature of episodic memory. More recently, Buckner and Carroll (2007) have suggested that theory of mind may share this characteristic of mentally projecting oneself into another time or place, and that these functions may rely on a common set of processes that allow past experiences to be 'used adaptively to imagine perspectives and events beyond those that emerge from the immediate environment'. It is this ability to shift perspective that Buckner has referred to as self-projection, and Mesulam (2002) noted that the prefrontal cortex (PFC) might be vital for the ability to 'transpose the effective reference point (of perception) from self to other…and from now to then'. There have been suggestions that the anterior PFC might play a role in regulating such shifts between perspectives.

Recent work by Simons and colleagues has investigated whether the anterior PFC may be involved in reality monitoring, the process used to decide whether information had an external or an internal source. It has been demonstrated that the lateral aspect of anterior PFC has a role in contextual recollection regardless of the type of context being retrieved, whereas the medial aspect is sensitive to the recollection of context details that are internally generated. Activation in this area was significantly greater when participants were required to determine whether a stimulus had been perceived or imagined than when they attempted to recollect stimulus position (Simons et al. 2006).

It seems that activity within the medial anterior PFC (maPFC) can be even further fractionated. In a study by Vinogradov and colleagues (2006), BOLD signal changes were provoked in its caudal aspects by tasks associated with correct recollection of source for self generated rather than experimenter generated words. Here, individuals may judge whether information retrieved includes traces of internal cognitive functions such as thought and imagination (Johnson et al., 1993). More caudal right medial activation may thus occur during self-reflection, whereas more anterior left medial activation may reflect the identification of events as having been imagined (Turner et al. 2007).

Consistent with this, BOLD signal changes have been observed in areas very close to those reported by Vinogradov in mentalising tasks that require reflection on one's own emotions and mental states, or those of others. Evidence from functional imaging studies of tasks that require participants to simulate another person's perspective was reviewed by Gallagher and Frith (2003), who suggested that these tasks recruit the anterior paracingulate cortex. They concluded that activity in this region of the medial PFC is crucial to 'determine (another's) mental state…that is decoupled from reality, and to handle simultaneously these two perspectives on the world' (It has also been suggested, however, that mentalising tasks activate the medial PFC simply because they are intrinsically difficult and involve components typical of executive tasks (Gallagher and Frith 2003). This seems unlikely, as Rowe and colleagues (2001) found that patients with frontal lesions had difficulties with mentalising tasks that were independent of problems they had with executive tasks).

This is reminiscent of the regulation of shifts in perspective necessary for the monitoring of memory also subserved by this region. Moreover, Simons observed greater activation for self-experimenter (S-E) than perceived-imagined (P-I) judgements in the region of maPFC previously linked with mentalising (Simons et al., 2008). Both of these forms of reality monitoring require the participant to distinguish internally generated and externally derived information. However, they differ in that the former relates to the self only, whereas the latter relates to two different agents. It may be that the processes involved in mentalising might be specifically recruited in the latter case.

It thus seems that the network involved in self-projection generalises beyond traditional memory tasks to those that involve mentalising. This hypothesis is further supported by a study by Saxe and Kanwisher (2003; from Buckner and Carroll, 2007) in which considering the beliefs of another agent strongly activated the network shared by remembering, whereas other forms of imagination (as exemplified by the false photograph task) did not. It may be that 'mental simulations that involve the interactions of people…are achieved by projecting our own mental states into different vantage points, in an analogous manner to how one projects oneself into the past and future' (Buckner and Carroll 2007).

In light of the research described, this study aims to address several questions. First, it aims to determine whether a positive correlation between performance on a reality monitoring task (which allows measurement of both S-E and P-I accuracy) and on two theory of mind tasks can be observed in the general population. Such a correlation would be expected if they are both forms of self projection that rely on a common set of processes. However, given that the concept of a common set of processes seems to contradict the findings about separable forms of reality monitoring supported by subregions of the maPFC, a more specific prediction is required. Since mentalising and agency discrimination seem to produce activation in a more caudal area of maPFC than does determining P-I status, it is predicted that any observed positive correlation between performance on theory of mind tasks and agency discrimination will be significantly larger than any positive correlation between theory of mind and determining P-I status, if one is observed. A further question is whether any correlation observed will generalize across mentalising tasks, or whether differential correlations will emerge, suggesting the possibility of fractionation in that domain as well.

METHOD

Participants

90 native speakers of English took part (28 men, 62 women). The mean age was 23 (range 18-40, s.d. 5.77), and the mean number of years of education was 16.41 (range 13-23, s.d. 1.89). Sixtythree of the participants were undergraduates or graduates at the University of Cambridge and 27 were from other backgrounds; the majority were staff at the University of Northumbria and Durham County Council.

Design and procedure

1. Memory task (Adapted from Simons et al. 2008):

Participants were first familiarised with the paradigm during a practice session. In the study phase, each participant was presented with 3 blocks of well known word pairs, with 32 pairs in each block. Each trial began with a cue indicating who would perform that trial. After 500 msec, either a complete word-pair (e.g. 'Laurel and Hardy') or an incomplete word-pair (e.g. 'Laurel and ?') was presented on the screen. If the cue 'SUBJECT' had been presented, the participant was instructed to read the whole word-pair out aloud (perceive condition) or to imagine the second word of the word-pair before reading the whole word-pair out aloud (imagine condition). If the cue had been 'EXPERIMENTER', the experimenter performed the perceive or imagine tasks and read the word-pair out aloud. The subject/experimenter and perceive/imagine conditions were crossed as experimental factors, with trial order pseudorandomised so that no more than 3 consecutive trials were of the same condition.

Test phases consisted of 3 blocks of 32 trials, each divided into 4 blocks of 8 trials each and preceded by an instruction indicating the type of judgment required. Participants were presented with the first word of a previously studied pair, and judged whether the accompanying word (which was not presented) had been perceived or imagined in the study phase, or whether they or the experimenter had read the word-pair out aloud. Participants indicated their response by pressing one of two keys on a keyboard, holding down the key to indicate their confidence. They had 4.5 seconds to do so, and a confidence bar at the bottom of the screen illustrated to participants their confidence rating, increasing in size as the key was held down. Perceive/imagine and self/experimenter status was systematically counterbalanced between participants, as was the ordering of test conditions and the type of recollection cued.

2. Faux-Pas Recognition test (Stone et al. 1998, Gregory et al. 2002, Baron Cohen et al. 1999):

Each participant studied 20 short stories taken from the adult version of the Faux-pas recognition test (Stone and Baron-Cohen). 10 stories contained an example of a Faux-pas (in the final part of the text or embedded in the body), the remainder did not. Each story was read aloud to the participant while they followed it on their copy. They were then asked a series of questions to assess their understanding of the Faux-pas.

3. Revised version of the adult Reading the Mind in the Eyes test (Baron Cohen et al. 2001):

The participant was presented with a series of 36 photographs of the eye region of actors and asked to choose which of 4 words best described what the person was thinking or feeling. They were encouraged to consult the glossary of mental state terms provided if unsure of a word's meaning. Baron-Cohen suggests that this is one of the few tests that can measure if an adult with normal intelligence may have a mild deficit in social understanding. This test provides a larger window for observing individual differences than the original version and should avoid ceiling effects as it is limited to complex mental states, items that can be solved just using gaze direction are excluded, and foil words have the same emotional valence as the target word.

RESULTS

Comparing FP scripts revealed differences in marking patterns between experimenters, which is to be expected as the marking of the test is reasonably subjective. To ensure inter-rater reliability, a random sample of scripts were swapped and marked blind to the score already awarded, ensuring scores given independently were well correlated. Differences were resolved by discussion and scripts were rescored accordingly. However, for 9 subjects there were insufficient details to allow rescoring. For analyses involving FP test, only the remaining 81 subjects were included. Subjects who were more than 3sd away from the mean score on a task were designated as outliers and excluded from comparisons involving that task. A further 4 subjects were excluded only for comparisons involving P-I, as they stated that they had not followed the instructions correctly on those trials.

Following exclusion of the relevant participants, a Pearson's test revealed that the correlation between score on the FP questions in the FP stories and S-E accuracy was significant [r(78)=0.259, p=0.05], whereas the correlation between score on the FP questions in the FP stories and P-I accuracy was not significant [r (75)=0.151, p=ns] (although the difference between the two correlations did not reach statistical significance as measured by Williams' (1959) test for non-independent correlations [t (73)=0.93, p=ns]).

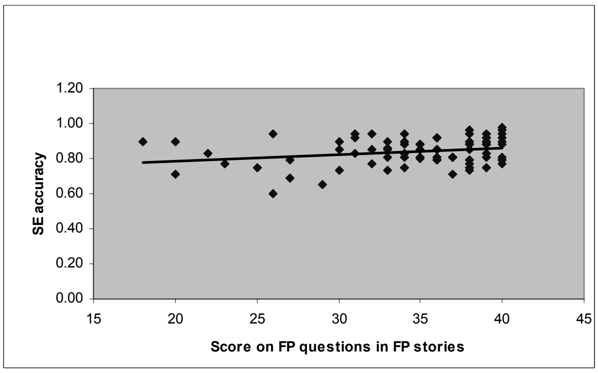

Figure 1. Scatter Plot illustrating the significant correlation between FP and SE

Examining the results involving the eyes test revealed no significant correlation between score on the eyes test and P-I accuracy [r(84)=0.114, p=ns] or S-E accuracy [r(88)=0.40,p=ns]. There was also no significant correlation between score on FP questions in FP stories and score on the eyes test [r(79)=0.064, p=ns]. Thus, there was a strong trend towards a significant difference between correlation of the two mentalising tasks and S-E accuracy, t (76) =1.438, p=0.077. To assess the reliability of these findings, Levene's Test of Normality was performed. This demonstrated homogeneity of variance for FP and S-E. Histograms and Q-Q plots for S-E and P-I revealed distributions that approximate normal ones. In the case of FP, a perfectly normal distribution was not expected as the task was not designed with this in mind. It is a clinical test not primarily intended for use in the general population. Since the aim is simply to demonstrate sufficient variability in the task so that a significant correlation cannot be due to a grossly skewed distribution (Poldrack 1996), it was agreed that these results could be accepted.

The nature of the misattribution errors themselves was then investigated. These include judging imagined stimuli as having been perceived (I as P), perceived stimuli as having been imagined (P as I), self generated stimuli as having been experimenter generated (S as E, or externalising errors) and experimenter generated stimuli as having been self generated (E as S, or internalising errors). There was a significant negative correlation between FP and E as S [r(78)=-0.230, p<0.05], but not between FP and S as E [r(78)=-0.204, p=ns], although the difference between the two correlations didn't reach statistical significance as measured by Williams' test [t (73) =0.18, p=ns]. No significant correlation between FP and P as I [r (75) =-0.092, p=ns] or I as P [r (75) =-0.074, p=ns] was observed.

Possible confounding factors that could be argued to account for the significant findings were then examined. There were no significant correlations between the FP score and age [r (79) =-0.168, p=ns], date tested [r(79)=0.131, p=ns] or years of education [r(80)=0.107, p=ns]. In addition there was no significant effect of gender on FP score, [t (78) =-1.38, p=ns]. There were also no significant correlations between S-E scores and date tested [r (88)=-0.050, p=ns] or years of education [r(89)=0.037, p=ns], nor was there a significant effect of gender on S-E accuracy, [t (87)=-0.235, p=ns]. As would be expected, there was a significant negative correlation between age and SE [r (88)=-0.312, p <0.01] and between age and PI, [r(84)=-0.236, p <0.05]. Since the correlation is present for both SE and PI but not for FP, it was concluded that this finding does not reduce the reliability of the main finding. A discussion of the effects of aging on memory is beyond the scope of this report and will not be considered further.

DISCUSSION

The results of this study showed a positive correlation between memory and theory of mind in the general population. This correlation was specific to the FP test rather than the eyes test, and there was no correlation between performance on the mentalising tasks. The effect was significant for S-E but not for P-I. The results could not be attributed to differences in age, date tested, years of education or gender. Thus the link between these functions does seem to be specific, perhaps attributable to a common set of processes relating to what has been termed 'self projection' (Buckner & Carroll, 2007). There was a negative correlation between FP and E as S misattribution errors, but no significant correlation with any of the other error types.

The results are consistent with the differences in activation reported by Simons and colleagues (2008), where the medial prefrontal brain area associated with S-E and mentalising was more caudal than the area associated with P-I. As predicted, the correlation observed in the present data seemed to be specific to the S-E condition.

Given these results, the question of why mentalising might be useful for episodic memory arises. The internal operations associated with simulating mental states may provide cues that are helpful for recollecting whether it was oneself or another person who read out a word pair, with reflecting on our own mental states forming part of the process of self monitoring. Gallagher and Frith (2003) have suggested several reasons for the opposite direction of link, that is, for why episodic memory might be useful for mentalising. We might remember episodes in which the behaviour we are observing was associated with a particular mental state, or use memory to generate scripts that enable us to anticipate another's goals in particular situations. We might also draw on past experience to imagine ourselves in the situation of another person and 'simulate' their experience (Harris, 1992).

A caveat is necessary, as the positive correlation between memory and theory of mind did not seem to apply to the eyes test. A study by Baron Cohen and Ring (1999) suggested that the left amygdala, rather than medial PFC, may be critically involved in identifying mental state information from the eyes. In comparison, there may be a greater frontal contribution to the FP test, perhaps because the participant must represent two mental states: that the person committing a faux-pas doesn't know they shouldn't say it *and* that the listener would feel insulted or hurt. Consistent with this, a study by Stone *et al.* (1998) found that patients with bilateral damage to the orbitofrontal cortex (OFC) were impaired on the FP test but performed well on standard first and second-order false belief tasks. Perhaps, then, theory of mind is not a likely candidate for localisation to a single brain area, but is served by a network of structures that make varying contributions and are involved to differing degrees in different tests. Thus it may be the case that the eye test and the FP test tap different processes, consistent with the finding that scores on these tests did not correlate. It is perhaps for this reason that a correlation between the eyes test and S-E was not observed.

CONCLUSION

This study is consistent with the possibility that mentally projecting oneself to vantage points that allow the simulation of perspectives distinct from those that are immediately apparent may be a feature of both memory and theory of mind. A positive correlation between memory and performance on the faux pas test was observed, and the observed trend towards a greater effect for agency discrimination is consistent with recent imaging studies. Until recently, cognitive functions such as memory and theory of mind have generally been considered distinct and have thus been studied as such. This may no longer be appropriate, and considering the relationship between them may prove not only informative but also exciting.

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