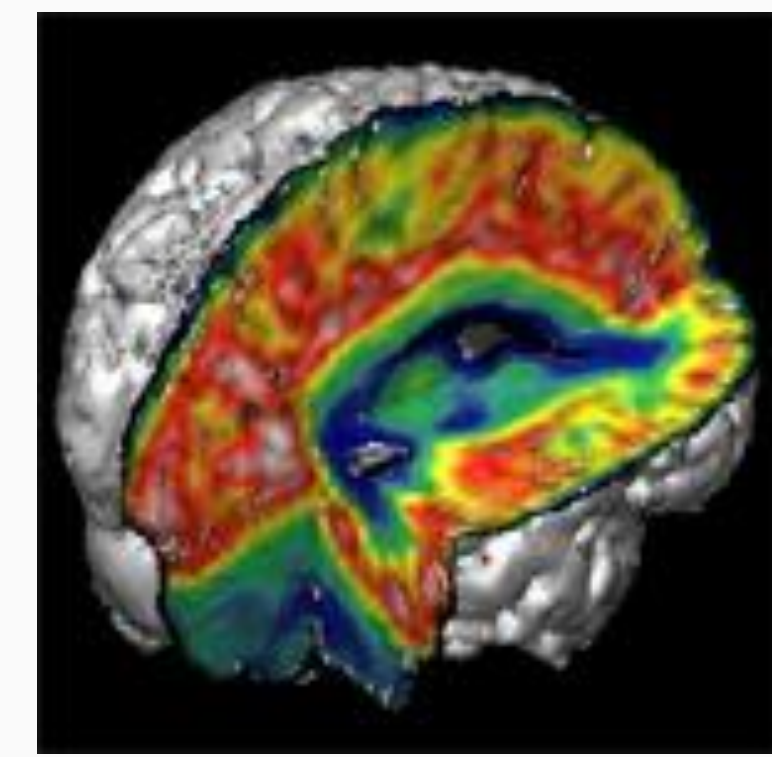




Moral cognition and serotonin:

No association with the 5HT_{2A} receptor; a possible association with the serotonin transporter



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BACKGROUND

Serotonin has been linked to emotional and social behavior, including social status and aggression, but only in very few studies specifically to moral behavior.

Lesion and fMRI studies indicate that specific brain regions are important for judgments of what is morally acceptable: medial and orbital frontal cortex, anterior cingulate cortex, and amygdala.

In moral dilemmas, Crockett et al. (2010) found that normal subjects given citalopram became less willing to endorse utilitarian solutions, which was interpreted in terms of enhanced harm avoidance. Others have found that subchronic SSRI treatment rendered healthy subjects more cooperative in social interaction paradigms. These studies do not, however, suggest the mechanism by which changes in serotonin may affect behavior, i.e. through SERT or postsynaptic receptors.

OBJECTIVE

Here, in a group of healthy individuals, we evaluated the association between two measures of moral cognition and SERT and 5-HT_{2A} receptor availability, as measured with PET.

METHODS

41 subjects (11 females; mean age 37.4 ± 21.4, range 20-82 years). Mean level of education was 15.2 ± 2.6 (range 8 - 17).

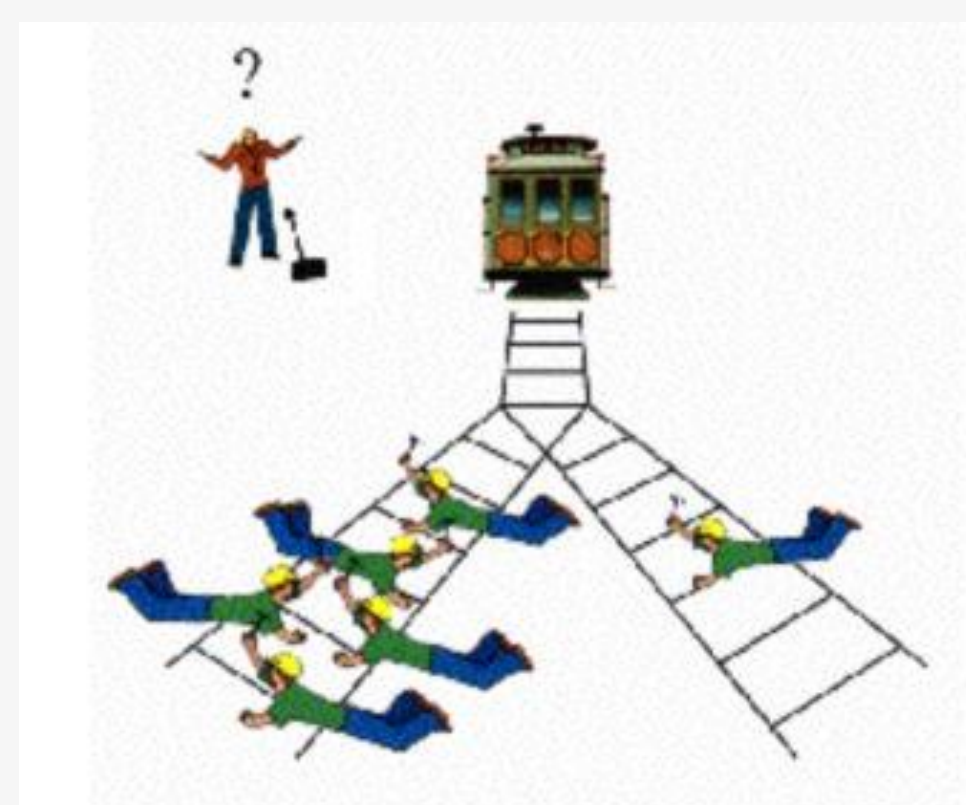
Moral Behavior Inventory

In the Moral Behavior Inventory (MBI), a 24 item questionnaire first described by Mendez et al. (2005), the subject is asked to rate each item on a Likert scale from 1-4 (1: not wrong; 4: very wrong): "How wrong is it if you": "fail to keep minor promises", "always let others pay at a restaurant", "take credit for others work" etc. The total score (maximum 96) is the sum of scores on all items.

Moral dilemmas

... were translated from Greene et al.'s study (2004). "Personal" refers to dilemmas in which the person is more personally involved than in the "impersonal" ones. An example of an impersonal dilemma is the trolley dilemma in which the subject must decide whether it is appropriate to pull a switch that will result in the trolley changing track and running into one instead of five workmen. All subjects read four impersonal and five personal dilemmas. "Yes" responses to both types of dilemmas may be considered utilitarian answers, and we combined them in one score.

Trolley dilemma:



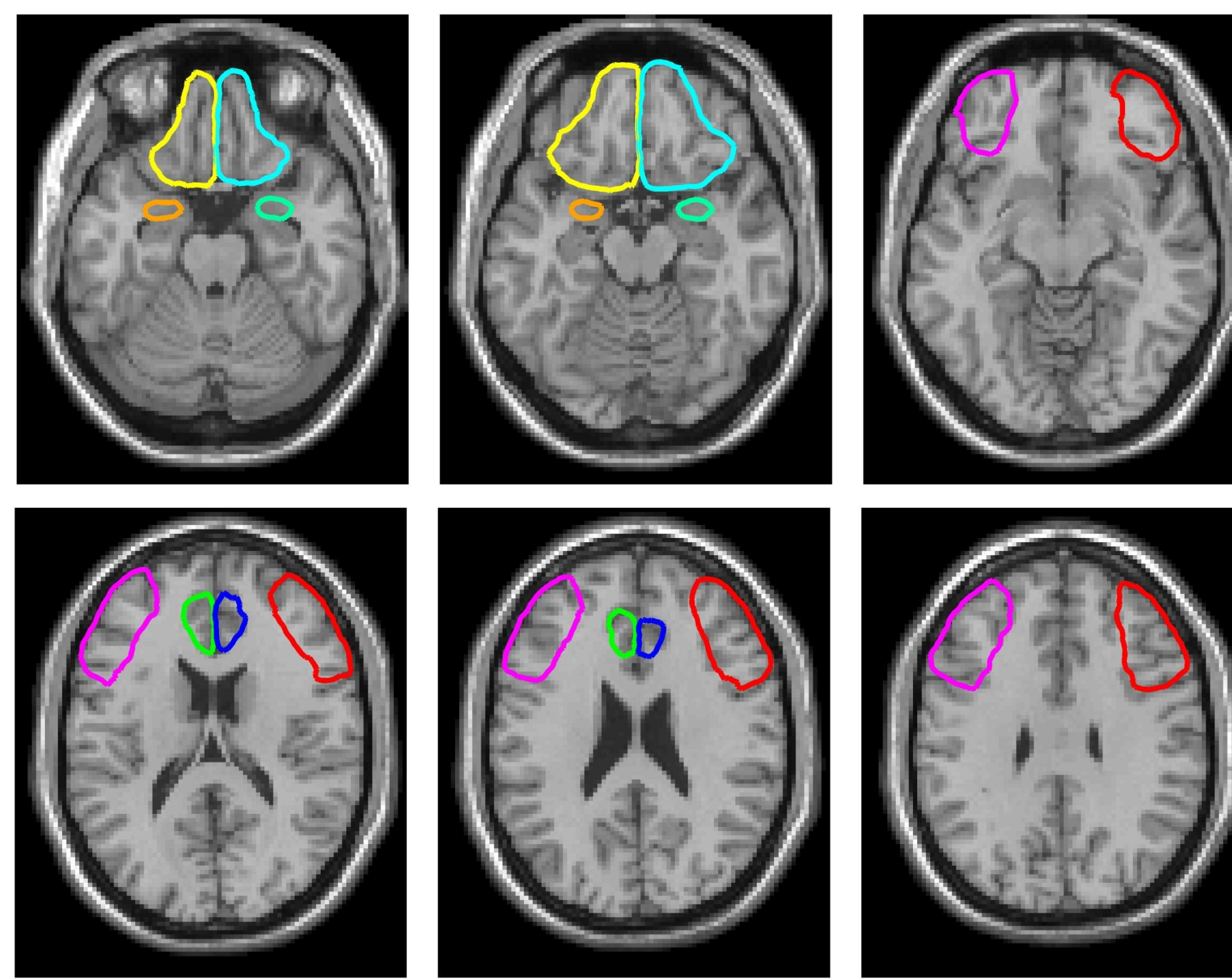
Imaging - PET

Positron Emission Tomography (PET) scans were conducted on an 18-ring GE-Advance scanner. [¹⁸F]Altanserin was used to measure the cerebral 5-HT_{2A} receptor binding, and [¹¹C]DASB to measure SERT binding.

Regions of interest

...are shown in the figure. For altanserin, correlations between ROIs were high, and frontal regions were combined. For SERT binding, individual ROIs (amygdala, inferior and middle frontal gyri, OFC and ACC) were used.

Regions of interest. Anterior cingulate is dark blue and green



Statistical Analyses

Partial Pearson correlations controlling for the effect of age (and both with and without gender) were conducted to examine the association between moral cognition and SERT and 5-HT_{2A} receptor binding within each ROI

RESULTS

5-HT_{2A} receptor binding and moral cognition

We performed four separate correlations between the scores of MBI and utilitarian answers in Moral Dilemmas on the one hand, and 5-HT_{2A} receptor binding in the amygdala and frontal cortex on the other. None of the correlations were significant, not even at trend level.

SERT binding and moral cognition

MBI and utilitarian answers in moral dilemmas were each correlated with SERT binding in four regions: amygdala, inferior and middle frontal gyri, ACC and OFC. In three regions correlations were non-significant. In the anterior cingulate cortex, MBI and SERT binding correlated negatively ($r = -.336$; $p = .035$), and utilitarian answers correlated positively ($r = .369$; $p = .021$)(figure). These correlations decreased when gender was also included as a covariate, and became non-significant. Also Bonferroni correction rendered the correlations non-significant.

CONCLUSION

In partial correlations corrected for age, we found no associations between 5-HT_{2A} receptor binding and the moral scores.

In one of four regions of interest, the anterior cingulate cortex, high SERT binding was associated with both utilitarian answers to moral dilemmas and low scores on the MBI, indicating a permissive attitude to moral behavior. These results did not survive correction for either gender or multiple tests, and thus should be considered preliminary.

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Plots of results. Green: males. Blue: females

