Neuroticism Predisposes to Donation more than Agreeableness: an fMRI study

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Abstract

Using functional magnetic resonance imaging (fMRI) in study 1, we examined the effect of two personality dimensions related to altruism such as Agreeableness and Neuroticism on the neural response to videos including images of situations from developing countries and audios of sentences employed by NGOs to demand help. For all the participants, the brain response across the whole brain was not significantly

different in the Donor and Control videos. Multiple regression analyses revealed that while Agreeableness was related to activation of mentalizing brain areas (i.e., the precuneus), Neuroticism was related more to activation of the brain areas related to reward and donation. Study 2 was a psychometric study and confirmed that Neuroticism showed greater association with donation behavior and sponsoring children from developing countries than Agreeableness. Our results may serve to gain a better understanding of the relationship between personality traits and altruistic behavior.

Keywords: personality, brain, altruistic behavior, Agreeableness, Neuroticism

Altruism is the renunciation of the self, and an exclusive concern for the welfare of others. Altruistic behavior may be accompanied (i.e., intentional altruism) by the moral obligation to a specific situation, or not (i.e., altruistic impulse). Recent neuroimaging studies have begun to explore the neurobiological basis of cooperation in interpersonal exchanges and altruistic behavior (Moll et al., 2005a). This review localized the processing of moral reasoning leading to altruistic behavior in the prefrontal cortex and the (anterior) temporal lobe. In a seminal study, Moll et al. (2006) identified several brain areas related to altruistic behavior. One relevant result found was that the mesolimbic reward system is similarly involved in reward decisions toward oneself or others. In addition, the adjacent subgenual area is specifically engaged by donations to others (i.e., social attachment). Finally, the more anterior sectors of the prefrontal cortex are distinctively recruited when altruistic choices prevail over selfish material interests. Recent research has related the activity of the subgenual area with feelings of guilt and compassion (Zahn et al., 2009).

One of the main focal points of interest in altruism is to know personality traits that are predisposed to donation. Currently, the most popular model of personality structure is the Five-Factor Model, which posits exactly five major, independent personality factors (McCrae & John 1992). Of these factors, Agreeableness has been defined as a bipolar dimension ranging from cooperative/kind on one extreme to cold/unsympathetic on the other, and was proposed to be related to altruistic behavior. Evidence in favor of this relationship has been found in some studies (Ashton et al., 1998; Osinski, 2009), but negative results have also been reported in others (Ben-Ner & Kramer, 2011). Agreeableness has also been positively related to the intention to give money to charity (Paunonen & Ashton, 2001). Similarly, a negative relation has been found between

Agreeableness and generalized prejudice (Ekehammar & Akrami, 2003), which suggests that agreeable individuals do not develop negative attitudes toward the outgroup. In contrast, Neuroticism has been proposed to be positively associated with kin altruism; that is, a tendency to feel empathy and attachment toward others (Ahston et al., 1998; Ben-Ner & Kramer, 2011; Krueger, Hicks & McGue, 2001; Osinski, 2009). However, Neuroticism is also negatively associated with reciprocal altruism, which can be related to the tendency to forgive others (Ahston et al., 1998; Osinski, 2009).

The objective of the present study was to investigate the neural basis of the association between personality and altruistic behavior. In Study 1, we investigated the neural reactions to advertisements designed to help end poverty in developing countries as a function of Neuroticism and Agreeableness. Some authors have highlighted that it is important that these solidarity campaigns should have the aim of making the audience become aware so that it practices intentional altruism (Haidt, 2001; Narvaez & Rest, 1995; Moll et al., 2007), but their neural response is unknown. Based on previous behavioral results, we predicted that Agreeableness and Neuroticism would be associated with a stronger activation of the brain areas related to altruism (i.e., the anterior prefrontal cortex, the anterior temporal lobe, the reward system and the subgenual area). Designed as a follow-up to Study 1, Study 2 investigated the relationship between altruistic behavior and personality in a sample of employees.

Study 1

Methods

Participants

Eighteen undergraduates (8 females and 10 males; mean age = 21.90; range 19–31) were studied, who had previously provided written informed consent. The experiment was approved by the University Jaume I's Ethical Committee. All the subjects were right-handed and did not report any neurological and psychiatric disorders. All the participants completed the Spanish version of the NEO-FFI (Costa & McCrae, 1999; Manga et al., 2004). This inventory has 60 items that evaluate all the dimensions defined by the Big Five Personality Theory (Extraversion, Neuroticism, Openness, Agreeableness and Conscientiousness) on a five-point scale. The Spanish version of the NEO-FFI (see Costa & McCrae, 1999) already includes most of the items reconsidered after the review by Costa and McCrae in 2004.

fMRI paradigm

Participants were required to watch a 6-minute film and to remember the auditory sentences generated with the Text Aloud (V. 2.7) software using the 'George' voice. This software guarantees that the same voice is heard during the entire task. Using selected fragments from documentaries, we constructed a single videotape consisting of 18 contiguous 20-second segments that pseudorandomly alternated three different conditions: the donor condition, the control video condition and the fixation condition. Both the donor and control conditions presented videos of outdoor scenes showing people's ways of life in two different scenarios. The videos under both conditions did not differ in terms of the mean number of shots. The Donor condition presented videos showing explicit scenes of poverty in developing countries. The audio included sentences denouncing the situation of developing countries and invited people to donate money and help. The donor scripts were prepared from an initial analysis of large nongovernmental organizations (NGOs) advertising (e.g., Amnesty International,

UNICEF, OXFAM). The control video included images of New York showing mostly Afro-American people, as well as images of people involved in daily activities such as walking, shopping or playing with others. The audio explains the people's ways of life in New York. Finally, the fixation condition showed a black screen for 20-second periods.

A post scan test was used to evaluate attention during the scanning session. Participants listened to 18 randomly ordered sentences, which supposedly corresponding to the study scripts. Nine of the 18 sentences presented during the test had been listened to during the scanner paradigm. Nine other new sentences, with contents similar to those presented in the scanner, were interspersed with the present scripts. The test asked subjects to answer yes or no if they have previously listened the sentences presented or not.

fMRI Acquisition

Blood oxygenation level-dependent (BOLD) fMRI data were acquired on a 1.5T Siemens Avanto (Erlangen, Germany). Subjects were placed in the MRI scanner in a supine position. Their heads were immobilized with cushions to reduce motion artifacts. Stimuli were directly presented using Visuastim XGA goggles with a resolution of 800 × 600 (Resonance Technologies, Inc). Vision correction was used whenever necessary.

A gradient-echoT2*-weighted echo-planar MR sequence was used for fMRI in both tasks (TE = 50 ms, TR = 3000 ms, flip angle = 90º, matrix = 64 × 64, voxel size = 3.94 × 3.94 × 6, with 5 mm thickness and 1 mm gap). We acquired 29 interleaved axial slices parallel to the hippocampi plane covering the entire brain. Prior to the functional MR sequence, an anatomical 3D volume was acquired using a T1-weighted gradient

echo pulse sequence (TE = 4.9 ms; TR = 11 ms; FOV = 24 cm; matrix= 256 × 224 × 166; voxel size = 1 × 1 × 1).

FMRI data analysis

Data were analyzed using Statistical Parametric Mapping (SPM5). For each subject, the first two scans in each run were excluded from the analysis to dismiss any artifacts related to the transient phase of magnetization. Motion correction of functional time series was performed with subjects using a six-parameter rigid-body transformation to realign functional volume to the mean location image. Likewise, all the individuals' anatomical images were co-registered to the mean of their corresponding functional images using a rigid-body transformation. Images were then spatially normalized to the Montreal Neurological Institute (MNI) template by conforming to the Talairach orientation system after applying a 12-parameter affine transformation followed by nonlinear warping using basis functions. The computed transformation parameters were applied to all the functional images by interpolating to a final voxel size of 3 × 3 × 3 mm^3. Subsequently, images were spatially smoothed with a FWHM 6 mm isotropic Gaussian kernel.

A two-stage procedure was used for the statistical analysis. At the first level (fixed effects), the fMRI data of each individual participant were used to generate statistical contrast images after comparing the brain activation between each experimental condition and the control condition (Donor Condition > Fixation; Control Condition > Fixation; Donor Condition > Control Condition). The resulting three contrast images of the parameter estimates were used in the second-level analysis to explore task-related activations. The effect of personality measures of Agreeableness and Neuroticism was investigated through regression analyses. Statistically defined clusters of activation

were identified using whole-brain Monte Carlo simulations (the Alpha Sim program by AFNI) to achieve a corrected cluster threshold of $p < 0.05$. Specifically, clusters reaching a contiguous volume of, at least, 1243 mm^3 at a voxelwise threshold of $p < 0.005$ were considered significant at $p < 0.05$.

Results

Recognition performance was obtained during the post-scan test, in which scripts from the video and new scripts were presented. It is noteworthy that all the participants correctly identified and rejected 92.3% (SD = 3.86) of the scripts in this post-scan test, thus ensuring attention during the scanner task.

The mean Agreeableness score was 31.60 (SD = 5.85; range 19–40), whereas the mean Neuroticism score was 20.90 (SD = 6.65; range 8–34). These scores are similar to those reported previously in Spanish samples (Manga et al., 2004).

As expected, both videos activated the brain areas typically involved in audio and video processing (Figuer 1). To investigate whether the donor video evoked different responses to the control video, a whole-brain voxel-wise analysis was performed on the Donor > Control contrast. Importantly, the comparison of both videos did not yield any significant differences in neural activity at the predetermined threshold. Moreover, the reverse contrast (Control > Donor) did not yield any significant difference.

Two whole-brain regression analyses were also performed on the Donor > Control contrast images using personality dimensions scores (Agreeableness or Neuroticism) as a regressor with a cluster-corrected threshold of $p < 0.05$ (see the results in Figure 2). The whole-brain voxelwise analysis for Agreeableness yielded significant task-related

activations in the precuneus, whereas the analysis for Neuroticism revealed a positive and significant correlation in the nucleus accumbens and the subgenual cingulate cortex.

Study 2

Methods

Participants

A sample of 110 graduate students, postgraduate students and university staff was selected from a pool of 342 participants who accepted to participate in the study. The inclusion criterion involved having a stable job with a minimum monthly salary of 600 euros at the time of testing. The final sample consisted of 45 males and 65 females aged 22 to 56 years (M = 36.59; SD = 7.81). Salaries were from 600 to 1,200 euros, from 1,200 to 1,800 euros and more than 1,800 euros for 40%, 50% and 10% of the participants respectively. Additionally, 49% had completed secondary school and 51% were graduate students.

Measures

Altruism and solidarity were measured by asking participants six yes-no questions on donating, promoting social justice and volunteering behavior. With regard to donating, participants were asked whether or not they regularly donate money to NGOs, give 0.7% of their salary via taxes to NGOs and/or sponsor a child from a developing country. To measure promoting social justice, participants were asked whether or not they had previously made a purchase in fair trade shops and/or formally reported an injustice. Finally, participants were asked whether or not they currently volunteer or have previously volunteered for NGOs. Each question was treated separately in the analyses. All participants also completed the Spanish version of the NEO-FFI (Costa & McCrae, 1999; Manga et al., 2004).

Results

Mean scores for personality dimensions appear in Table 1 and percentages of yes responses to altruism questions appear in Table 2. Using chi-square analyses, we first tested the relationship between responses and sociodemographic variables such as gender, educational level and salary. All these analyses were nonsignificant with the exception of a positive relationship between sponsoring a child and salary ($X^2 = 6.14$, $p < 0.05$). We also used binary logistic regression to confirm that age had no significant influence on responses to solidarity questions. Finally, educational level and salary were not related to personality measures, and we only found gender differences for Agreeableness (see Table 1).

In order to explore the relationship between altruistic behavior and personality, we performed binary logistic regression analyses with responses to yes-no questions as dependent variables and personality measures as predictor variables. A forward stepwise (Wald) method was employed in which the predictor variables were successively added according to the magnitude of their correlation with the dependent variable, and then were successively removed until the predictive ability of the regression model, as indexed by the chi-square model, did not significantly improve. As expected, results showed that Neuroticism was associated with increased probability of donating money to NGOs and sponsoring a child in a developing country. Furthermore, Openness was related to buying in fair trade shops and reporting injustices. Finally, Agreeableness was only related to sponsoring children but not to the other altruistic items.

Discussion

The present work investigates the neural response to video demanding for help to end poverty in developing countries. Overall, the analyses reveal that both Donor and Control videos did not differ in brain response when considering the whole sample. Then, the functional differences between both videos may be better understood if we take into account individual differences in personality. The multiple regression analyses reveal that Agreeableness is positively related to enhanced response in the precuneus, whereas Neuroticism scores are related to a stronger activation of the nucleus accumbens and the subgenual area; that is, to the brain areas related to altruistic donation and feelings of guilt (Moll et al., 2006; Zahn et al., 2009). Given the relationship between Neuroticism and activation of brain areas related to reward during processing of the Donor video, Study 2 was designed to confirm that neurotic people do indeed exhibit altruistic behaviors..

For the aims of the present study, it is noteworthy that our data show that personality traits may influence the brain response to the Donor Video. Specifically, the Agreeableness dimension is associated with increased activity in those brain areas related to mentalizing, which strongly support the idea that this trait measures individual differences in proneness to altruistic or prosocial behavior, which is the opposite to antagonistic and antisocial behavior. This study demonstrates that the precuneus is more strongly activated in individuals with higher Agreeableness scores when paying attention to a video demanding help for developing countries. This area participates in different cognitive processes including visuo-spatial imagery, episodic memory retrieval, self-processing and consciousness, which are common in the mental representation of the self (Cavanna and Trimble, 2006; Overvalle & Baetens, 2009).

The precuneus also participates more intensely in emotional tasks, such as empathic judgments (Ochsner *et al*., 2004), interaction with others (Rilling et al., 2004) or in processing moral conflicts (Sommer et al., 2010). Thus, we can infer, in consonance with previous morphometric studies (Deyoung et al., 2010), that its role is related to the integration of emotions into social situations, which helps guide future decisions about moral dilemmas (Moll et al., 2005a).

With a sample of employees, Study 2 was designed to test if neurotic people do indeed participate in altruistic behaviors such as donating money to help others in real life. We found that Neuroticism was positively correlated with donating money to NGOs and sponsoring children in developing countries but not with other behaviors involving volunteering or promoting social justice. These results are in consonance with previous behavioral studies showing that Neuroticism was associated with feelings of empathy toward others (Ahston et al., 1998; Ben-Ner & Kramer, 2011; Krueger, Hicks & McGue, 2001; Osinski, 2009). On the other hand, Neuroticism scores are positively associated with activity in both the subgenual area and the accumbens nucleus while processing the video demanding help to end poverty in developing countries. Consistently with previous interpretations of the role of this area in moral decisions, we may speculate from these results that individuals with high Neuroticism feel more empathy and shame of others and, more importantly, they are more likely to make donations to help others (Moll et al., 2006).

Study 2 also showed that Agreeableness was associated with sponsoring children but not with the other altrusitic behaviors tested. This result was not consistent with previous behavioral experiments demonstrating that agreeable participants had a greater predisposition to prosocial and altruistic behaviors (Graziano et al., 2007; Osinski, 2009). However, in line with our results, participants high in agreeableness had less

probability of donating money to others in the dictator game (Ben-Ner, & Kramer, 2011). It is likely that Agreeableness is more related to showing positive attitudes toward others but less associated with donating behavior. Although less related to the objectives of our research, Study 2 also showed that the trait Openness to Experience was associated with buying more frequently in fair trade shops and formally reporting injustices, which seems to be in agreement with previous reports associating Openness to Experience with proneness to be politically liberal and tolerance for diversity (Jost, 2006).

The overview of our results enables us to conclude that the response to this kind of audiovisual messages is not unitary across subjects, but depends in part on personality differences. Therefore, the effects of NGOs' advertising should take these effects into account. Thus, we obtain a better explanation of the cognitive and neural response to donor messages when we study the influence of relevant personality factors. In this sense, we expect a good influence of Agreeableness, which is related to a stronger activation in the brain areas related to integration of emotional information, but not necessarily to feelings of guilt and donating money. In contrast, Neuroticism is a trait that seems to relate more to donation behavior. The results obtained in the present study should be considered when preparing media advertising campaigns.

Our findings on the modulating effect of Neuroticism and Agreeableness on moral processing are based on a correlation approach, which identifies relationships between variables, but does not permit causal interpretations. Therefore, we cannot rule out that the observed associations may have been conditioned by another not yet known or considered factor. Addressing divergent and convergent validity remains an open issue for future studies on the same topic to reinforce the observed findings. Another limitation of this study is sample size in Study 1 (n=18). We attempted to compensate

for this issue by performing the correlation analyses within a multiple regression approach and by imposing rather strict statistical thresholds.

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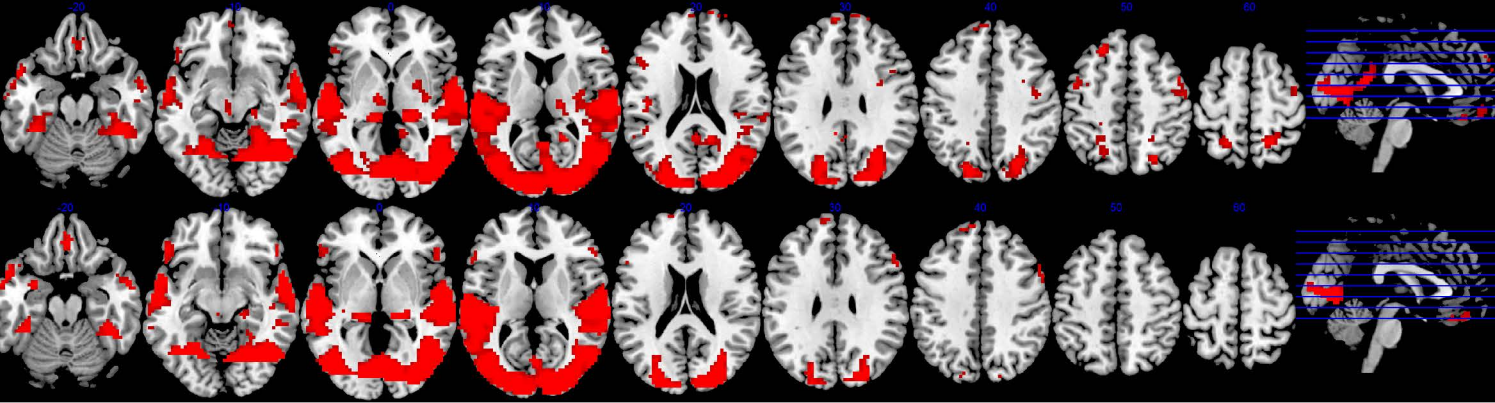
Figure Captions

Figure 1. Main effects on task. The Upper row represents the one sample t-test for Donor video vs. fixation contrast, whereas the lower row represents the one sample t-test for Control video vs. fixation contrast.

Figure 2. Brain areas that correlated positively with Neuroticism and Agreeableness traits.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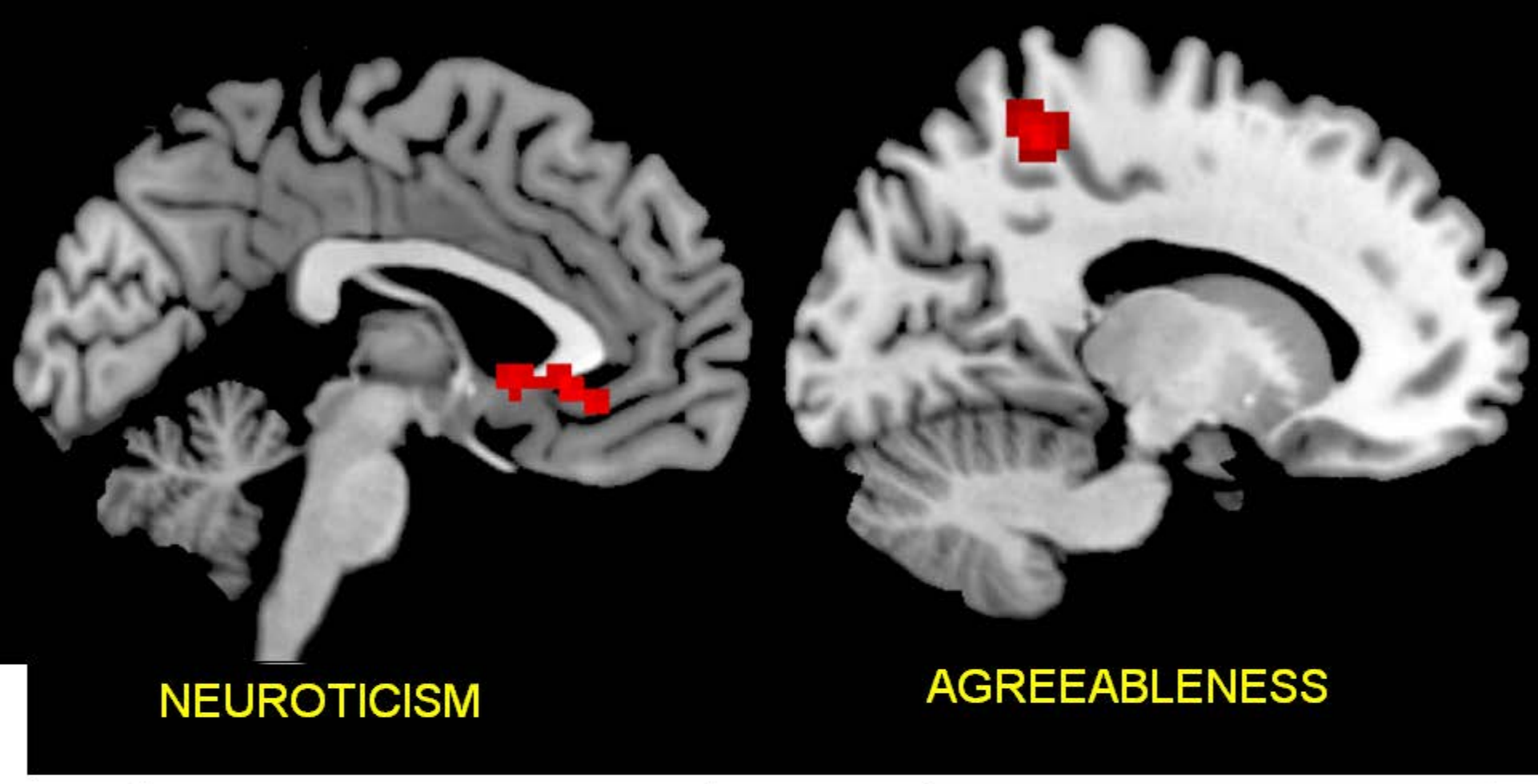
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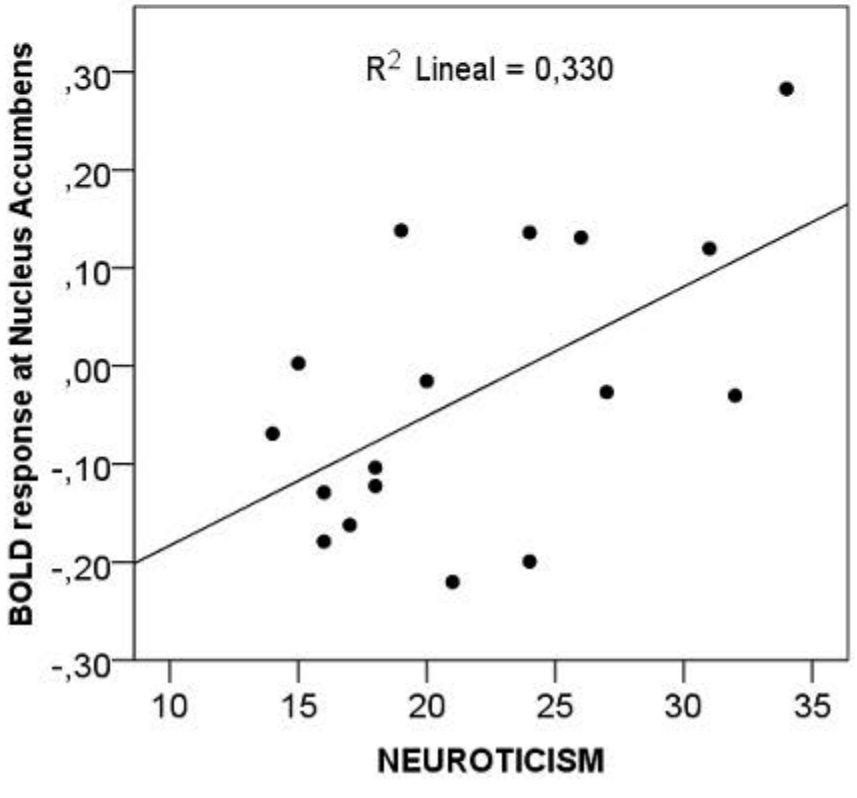
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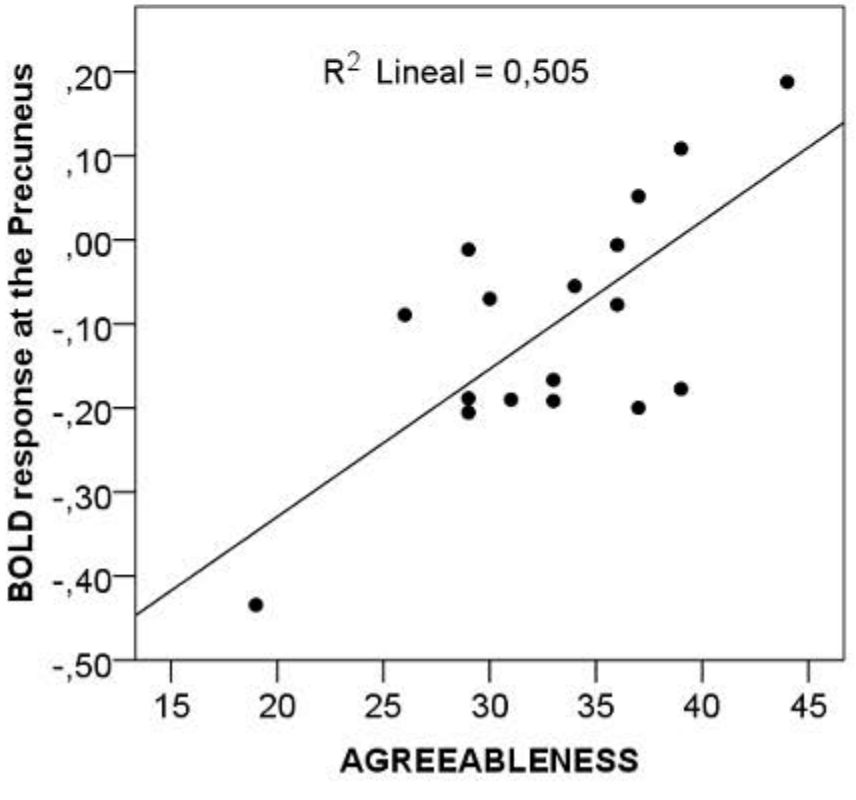
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Table 1.

Study 2: Means and standard deviation of personality traits.

Scale	Males	Females	Diff
Extraversion	28.84 (7.16)	29.35 (6.60)	ns
Neuroticism	21.06 (7.26)	19.81 (7.95)	ns
Openness to experience	29.50 (6.20)	29.38 (5.19)	ns
Agreeableness	31.56 (5.69)	33.72 (4.61)	$p < .05$
Conscientiousness	31.99 (7.37)	33.43 (5.82)	ns

Table 2.

Results of binary logistic regression analyses. R^2 = Nagelkerke R^2; OR= Odds ratio; CI= Confidence interval; Neu=Neuroticism; Agree= Agreeableness; Open= Openness to experience; NGO= Non-governmental Organization.

	Yes (%)	*R^2 (%)*	*χ^2*	*-2 Log Likelihood*	*Personality*	*OR*	*CI*
Donate money to NGOs	53	9	7.31**	144,85	Neu**	2.24	1.22-4.16
Sponsor a child	18	20	14.51**	89.80	Neu** Agree*	4.39 4.32	1.84-10.45 1.10-16.93
Donate 0.7%	48	---	---	---	---	---	----
Buy fair trade shops	19	14	10.26**	97.00	Open**	5.76	1.84-18.02
Sign to Report Injusticies	49	7	6.06*	146.40	Open*	2.87	1.20-6.91
Volunteering	25	--	---	---	---	---	---