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Journal of Neuroscience, Psychology, and Economics

Neuroticism Predisposes to Donation more than Agreeableness: an fMRI study

--Manuscript Draft--

Manuscript Number:	NPE-2015-1113R1
Full Title:	Neuroticism Predisposes to Donation more than Agreeableness: an fMRI study
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.
Article Type:	Article
Keywords:	personality, brain, altruistic behavior, Agreeableness, Neuroticism
Corresponding Author:	Daniel Pinazo Universitat Jaume I SPAIN
Corresponding Author E-Mail:	pinazo@uji.es
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	Universitat Jaume I
Other Authors:	Barros-Loscertales Alfonso, Dr. Peris Rosana, Dr. Ventura Noelia, Dr. Avila Cesar, Proffessor
Author Comments:	
Corresponding Author's Secondary Institution:	
First Author:	Daniel Pinazo
Order of Authors Secondary Information:	
Manuscript Region of Origin:	SPAIN
Suggested Reviewers:	Eloisa Nos-Aldas, Dr. Universitat Jaume I aldas@uji.es Is an expertise in social communication
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Response to Reviewers:	NPE-2015-1113 Neuroticism Predisposes to Donation more than Agreeableness: an fMRI study Journal of Neuroscience, Psychology, and Economics Dear Dr. Pinazo, I have now received the reviews of your manuscript. The reviewers are advising that

you revise your submission addressing the points outlined in their critiques. If you are prepared to address these concerns, I would be pleased to evaluate your revision of this submission.

For your guidance, reviewers' comments are appended below.

If you do decide to revise the work, please submit a list of changes or a rebuttal against each point which is being raised when you submit the revised manuscript.

To submit a revision, go to <http://npe.edmgr.com/> and log in as an Author. You will see a menu item call Submission Needing Revision. You will find your submission record there.

Sincerely,
Bernd Weber
Editor
Journal of Neuroscience, Psychology, and Economics

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Reviewer #1: The authors conducted two independent studies to explore the relationship between personality traits (agreeableness and neuroticism), brain activation, and self-reported altruistic behavior. In study one, participants (n = 18) saw advertisement videos designed to help end poverty in developing countries (solidarity campaigns). The authors then explored whether people high in neuroticism or high in agreeableness differentially activate brain regions while watching these videos. Neuroticism correlated positively with brain activation in the nucleus accumbens and the subgenual cingulate cortex, whereas agreeableness correlated positively with brain activation in the precuneus. These brain regions are known to be associated with reward processing, guilt, and mentalizing, and have been previously associated with altruistic behavior, including donating real money to charities. In line with these findings, the authors demonstrate in a second, purely psychometrical study (n = 110) that both neuroticism and agreeableness are associated with self-reported altruistic behavior. Neuroticism correlated positively with the probability of donating money and sponsoring a child in a developing country. Agreeableness correlated positively with sponsoring a child in a developing country.

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Dear Editor,

Please find attached the manuscript entitled '**Neuroticism Predisposes to Donation more than Agreeableness: an fMRI study**' that we submit to your consideration to be published in **Journal of Neuroscience, Psychology, and Economics**

Sincerely,

Daniel Pinazo

*Department of Evolutionary, Educational, Social Psychology and Methodology, Jaume I University, Av. Sos Baynat, s/n, 12071- Castelló de la Plana (Spain).
Tel. +34 964 729715. Fax. +34 964 729267. E-mail: pinazo@psi.uji.es*

Alfonso Barros-Loscertales

*Department of Basic, Clinical Psychology and Psycobiology, Jaume I University,
Castellón, Spain*

Rosana Peris

*Department of Evolutionary, Educational, Social Psychology and Methodology,
Jaume I University, Castellón, Spain*

Noelia Ventura-Campos

*Department of Basic, Clinical Psychology and Psycobiology, Jaume I University,
Castellón, Spain*

César Ávila

*Department of Basic, Clinical Psychology and Psychobiology, Jaume I University,
Castellón, Spain*

Acknowledgments

This study has been supported by two grants from the Spanish Ministry of Science and Technology (the BrainGlot Project, reference CSD2007-00012 of the Consolidation-Ingenio 2010 program), and the grants PSI2010-20168 and P1·1B2008-35 given to CA.

Conflict of interest: None declared.

NPE-2015-1113

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Neuroticism Predisposes to Donation more than Agreeableness: an fMRI study

**Daniel Pinazo¹, Alfonso Barros-Loscertales², Rosana Peris¹, Noelia Ventura-
Campos², & César Ávila²**

*1 Departamento de Psicología Evolutiva, Educativa, Social y Metodología, Universitat
Jaume I Castelló, Spain*

*2 Departamento de Psicología Básica, Clínica y Psicobiología, Universitat Jaume I
Castelló, Spain*

Correspondence should be addressed to: César Ávila, *Departamento de Psicología
Básica Clínica i Psicobiología, Universitat Jaume I, Av. Sos Baynat, s/n, 12071-
Castelló de la Plana (Spain). Tel. +34 964 387662. Fax. +34 964 729267. E-mail:
avila@psb.uji.es*

WORDS: 5,373

NUMBER PAGES: 18

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. Other brain areas related to reward evaluation such as the lateral OFC and more anterior sectors of the prefrontal cortex were distinctively recruited when altruistic choices prevail over selfish material interests. As well as brain areas directly involved in reward processing, other areas, such as the subgenual area, were specifically engaged by donations to others (i.e., social attachment) in this study. Previous studies have related the activity of the subgenual area with mentalizing (Waytz et al., 2012) and specifically with feelings of guilt and compassion (Zahn et al., 2009). Also, activity in other medial parts of the prefrontal cortex such as the dorsomedial area during reflexive engagement about oneself predicted altruistic decisions (Waytz et al., 2012). Finally, recent studies have demonstrated that GM volume and activity in the right temporo-parietal junction predicted individual differences in behavioral altruism in situations of advantageous inequality (Hare et al., 2010; Morishima et al., 2012). Overall, altruistic behavior seems to be related to activity in the reward system, but more specifically to areas related to mentalizing about oneself and to perspective-taking tasks such as the dorsomedial prefrontal cortex, the subgenual area and the temporo-parietal junction.

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 reward system, the subgenual area, **the medial parts of the prefrontal cortex or the temporoparietal junction**). 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 = 90°, 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 mm³. 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 mm³ 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).

(Here 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. **Results of the association between each personality and the dependent variables appear on Table 2.** 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 **(see Table 3)**. 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.

(Here Table 2)

(Here Table 3)

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 altruistic behaviors tested. This result was not consistent with

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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. A further limitation of study arises from the use of hypothetical scenarios that were not examining real behavior (i.e. participants did not donate real money to charities).

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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.

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 = 90° , matrix = 64×64 , voxel size = $3.94 \times 3.94 \times 6$, 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 = $256 \times 224 \times 166$; voxel size = $1 \times 1 \times 1$).

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 $3 \times 3 \times 3$ mm³. 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 mm³ 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 (Figure 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.

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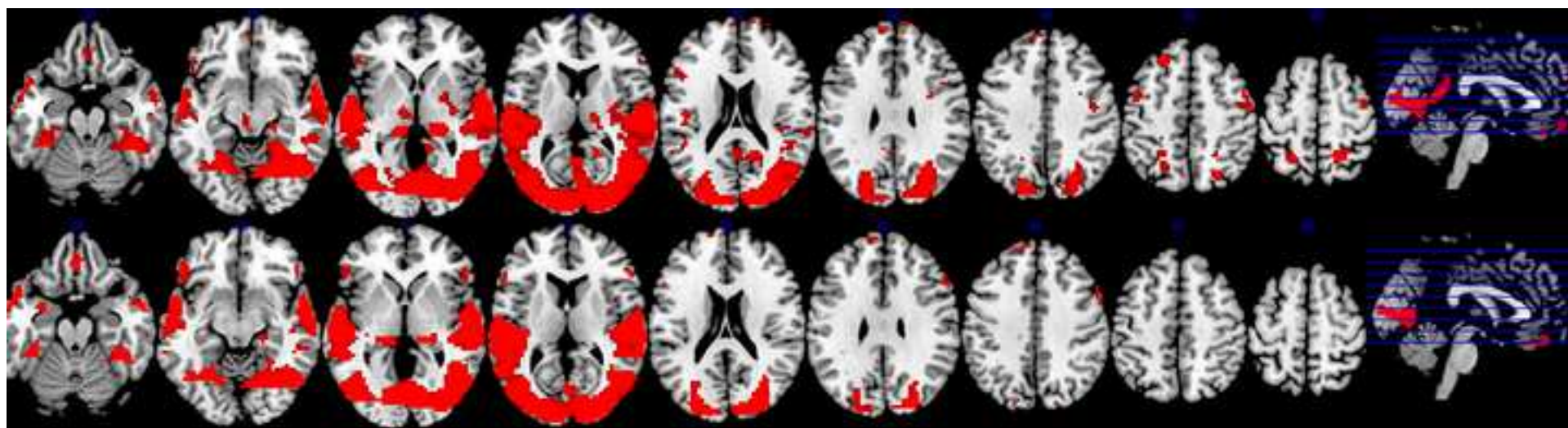
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Figure Captions

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.

Figure



Figure

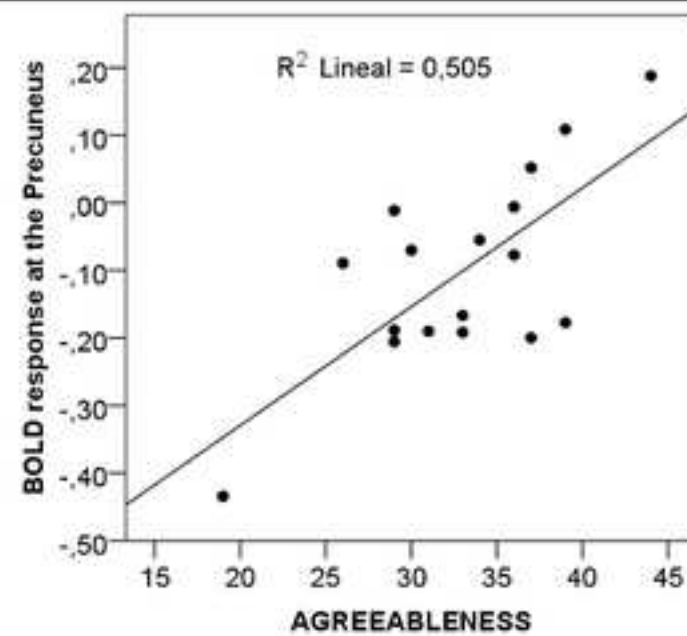
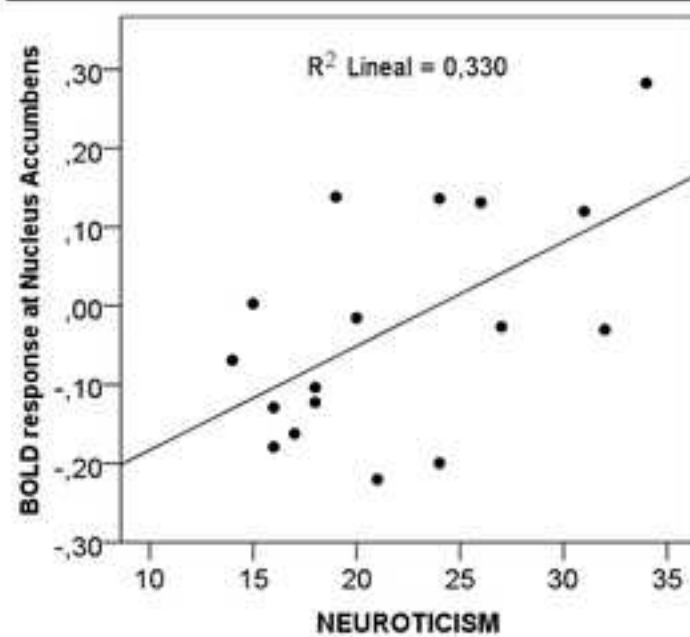
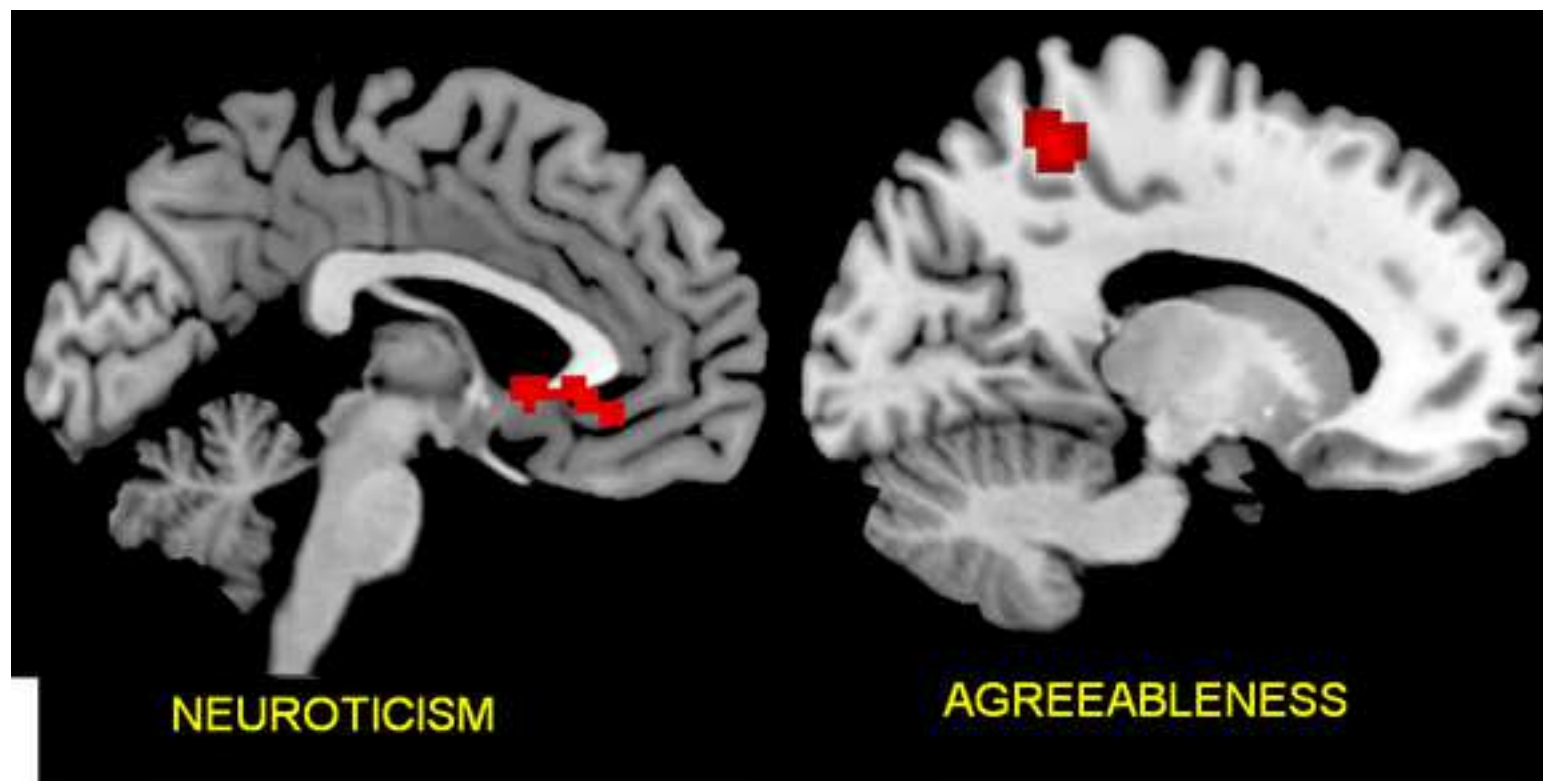


Table 1.

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.

Odds ratio and confidence interval for each personality dimension on Neuroticism, Agreeableness, Openness to experience, Non-governmental Organization.

	Extraversion	Neuroticism	Agreeableness	Openness to experience	Conscientiousness
Donate money to NGOs	1.08 (.49-2.73)	2.24** (1.22-4.16)	1.37 (.49-3.85)	1.29 (.53-3.16)	1.30 (.58-2.91)
Sponsor a child	.91 (.31-2.71)	4.55** (1.63-12.68)	3.42 (.71-16.62)	5.43* (1.29-22.95)	1.71 (.52-5.64)
Donate 0.7%	.76 (.35-1.62)	1.02 (.53-1.93)	1.11 (.41-2.98)	1.20 (.51-2.84)	.79 (.36-1.73)
Buy fair trade shops	.73 (.25-2.12)	.98 (.42-2.32)	1.08 (.25-4.76)	5.76** (1.84-18.02)	1.70 (.36-5.49)
Sign to Report Injustices	.74 (.34-1.60)	1.21 (.62-2.34)	1.75 (.61-5.00)	2.87* (1.20-6.91)	1.02 (.46-2.31)
Volunteering	1.04 (.42-2.60)	.56 (.25-1.27)	.37 (.10-1.27)	.42 (.15-1.20)	.51 (.20-1.31)

* $p < .05$; ** $p > .01$

Table 3.
Results of binary logistic regression analyses.

			Yes (%)	R ² (%)	X 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**	4.39	1.84-10.45
							Agree*	4.32	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 Injustices			49	7	6.06*	146.40	Open*	2.87	1.20-6.91
Volunteering			25	--	---	---	---	---	---

R² = Nagelkerke; OR= Odds ratio; CI= Confidence interval; Neu=Neuroticism; Agree= Agreeableness; Open= Openness to experience; NGO= Non-governmental Organization.
* p < .05; ** p > .01

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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 (%)	X ²	-2 Log Likelihood	Personality	OR	CI
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Donate 0.7%			48	---	---	---	---	---	----
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Volunteering			25	--	---	---	---	---	---