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Agreeableness and brain activity during emotion attribution decisions

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ABSTRACT

Within the Big 5 model of personality, Agreeableness is a trait-dimension associated with the tendency to behave prosocially; highly agreeable people tend to be highly cooperative and altruistic. This study was designed to test for associations between Agreeableness and the way people decide the cause of another person's emotional reaction (emotion attribution). Behavioral and neuroimaging (fMRI) data were collected while participants (n = 72) performed an emotional attribution task. During the emotion attribution task, participants decided which of two social–emotional scenes they believed caused another person's emotional reaction. Converging evidence indicated that highly agreeable people tend to make emotional attribution decisions more quickly and exhibit greater temporoparietal junction activity during emotion attribution decisions, compared to low agreeable people.

1. Introduction

Personality neuroscience advances the way the biological bases of individual differences are understood (Canli, 2004; DeYoung, 2010; Read et al., 2010). Empirical research shows that personality traits within the Big 5 model of personality are associated with neural reactivity during cognitive and emotional processing (DeYoung, Shamosh, Green, Braver, & Gray, 2009; Haas & Canli, 2008). Agreeableness is one trait-dimension associated with prosociality (Graziano & Tobin, 2013). It is currently unclear however, how individual differences in Agreeableness may represent specific social–cognitive tendencies that facilitate prosocial behavior. This study was designed to investigate the association between Agreeableness and brain activity when inferring the cause of another person's emotional reaction.

Agreeableness is a trait that measures the tendency to be kind, sympathetic, cooperative, warm and considerate with others. A central feature of Agreeableness is the tendency to be cooperative and accommodating with other people with the goal of maintaining smooth interpersonal relationships (Graziano & Tobin, 2013). There is empirical evidence that Agreeableness is associated with social–cognitive functions that include empathy, theory of mind and perspective taking. For example, in terms of empathic accuracy, highly agreeable people are more accurate when inferring the emotional states of other people as compared to low agreeable people (Côté et al., 2011; Kraus, Côté, & Keltner, 2010). Specifically Côté et al. (2011) measured the accuracy of emotion recognition between partners during a social interaction task. Highly Agreeable participants were more accurate in recognizing their partner's emotions as compared to low agreeable participants. Other studies have demonstrated associations between Agreeableness and traits designed to measure empathy and perspective taking specifically. Graziano, Habashi, Sheese, and Tobin (2007) showed that Agreeableness is strongly associated with "other oriented" empathy even when partialling out the variance for each of the other Big 5 dimensions. Combined, these findings suggest that Agreeableness may be associated with the way mental states of other people are inferred.

Emotion attribution involves deciding the cause of another person's emotional reaction. If one is able to quickly decide the reason why another person is emotionally reacting, one may be better positioned to help the other person or to share in their joy. The process of emotion attribution may be an important factor underlying what makes some people more "prosocial" compared to others. Indeed, other related psychological constructs, such as empathy, theory of mind and perspective taking, facilitate cooperation within large groups and strengthen social relationships (Downey, Zaki, & Mitchell, 2010).

Deciding the cause of another person's reaction (emotion attribution) depends on a network of brain structures that include the temporoparietal junction (TPJ), medial prefrontal cortex and precuneus, often termed the mentalizing system (Haas, Anderson, & Filkowski, 2015; Spunt & Lieberman, 2012). The mentalizing system is linked to social cognitive processes that include empathy,

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theory of mind and perspective taking (Frith & Frith, 2006; Van Overwalle & Baetens, 2009). Recent neuroimaging research has demonstrated that the mentalizing brain system is involved during the processing of emotion and social attribution. Kelly, Webb, Meier, Arcaro, and Graziano (2014) used a combined functional Magnetic Resonance Imaging (fMRI) and transcranial magnetic stimulation (TMS) approach and demonstrated that activity within the TPJ increased when people made social attribution decisions. Spunt and Lieberman (2012) collected fMRI data while participants were presented with social–emotional videos and demonstrated that TPJ, medial prefrontal cortex and precuneus (among other brain regions) activity was increased when participants thought about *why* someone was emotionally reacting (cause) versus *how* someone was emotionally reacting (what). These findings show that the mentalizing brain system is important for thinking about the cause of other people's emotional reactions.

In this study, we collected fMRI data while participants ($n = 72$) completed an emotional attribution task. During the emotional attribution task, participants were instructed to make two different types of decisions (emotion attribution and gender match). During the emotional attribution condition, each participant was instructed to decide which of the two social–emotional scenes they believed caused another person's emotional reaction. During the gender match condition, each participant was instructed to match the proportion of gender of people within each social–emotional scene with the gender of the person in a photograph. In order to identify brain activity associated with emotion attribution, we compared fMRI signal during the emotion attribution condition to the gender match condition.

We tested for associations between Agreeableness (while controlling for the remaining Big 5 personality dimensions and sex and age) and brain activity during emotional attribution decisions. Based on evidence that Agreeableness is associated with cooperation and empathy, and with the ability to infer the mental states of other people (Côté et al., 2011; Graziano & Tobin, 2013; Graziano et al., 2007; Kraus et al., 2010), we predicted to observe that highly agreeable people would exhibit greater neural activity within the mentalizing brain system during emotion attribution decisions compared to low agreeable people.

2. Methods

2.1. Participants

We recruited 72, fluent English-speaking, right-handed (42 females, 30 males; mean age = 20.83 years, SD = 3.18 years, 72 right-handed) adults from the University of Georgia and surrounding community to participate in behavioral testing and neuroimaging. All participants were screened for neurological conditions and MRI counter indications. All participants provided written informed consent as detailed in the Declaration of Helsinki, and the University of Georgia Institutional Review Board approved all procedures within this study.

2.2. Procedure

Each participant completed the personality assessment in a laboratory within the Psychology Department at the University of Georgia. On a separate day, each participant completed the emotion attribution task while undergoing fMRI at the University of Georgia Bio-Imaging Research Center (birc.uga.edu). Prior to neuroimaging, each participant completed a brief practice version of the emotion attribution task. The mean duration (number of days) between the completion of the NEO and MRI scanning was 37.3 days (SD = 27.24).

2.3. Personality assessment

Each participant completed the NEO Personality Inventory-3 (NEO PI-3) (McCrae, Costa, & Martin, 2005a). The NEO PI-3 covers each of the Big 5 personality traits (Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness) and facets for each trait. Personality data were scored to represent *T*-values, with the population mean defined as $T = 50$ and one standard deviation of $T = 10$. Converting raw data to *t*-scores reduces age and gender effects (McCrae, Martin, & Costa, 2005b). An examination of the internal consistency for all items included for each trait dimension showed high internal consistency (Table 1).

2.4. Target and cause stimuli

For the emotion attribution task (Fig. 1), two types of stimuli were created and used within each single trial. Happy and sad emotional facial expressions, with varying intensity levels, were used as targets and images of social–emotional scenes were used as potential causes. The target emotional faces were selected from a standardized database (Lundqvist, Flykt, & Öhman, 1998), and were modified to produce variability in emotion intensity. Empirical research demonstrates that the intensity of emotional expressions is highly variable within and across people (Larsen, Diener, & Emmons, 1986). Facial expressions were morphed in order to produce variability between stimuli and to improve the ecological validity of the task. Variation of emotional intensity was carried out using morphing software (www.fantamorph.com). Each happy or sad face was morphed with an image of a neutral expression of the same identity. Half of the target faces were created to be "mild intensity" using a gradient of 30–40%: emotional–neutral and half of the target faces were created to be "high intensity" using a gradient 70–80%: emotional–neutral.

Images of social–emotional scenes (positive and negative emotional valence) were used as potential causes within the emotion attribution task. Each image of an emotionally provocative social scene was selected from either the Geneva Affective Picture Database (Dan-Glauser & Scherer, 2011) or the International Affective Picture System (Lang & Greenwald, 1993). Many of these social scenes have previously been used to investigate reactivity to social–emotional scenes (Vrtička, Sander, & Vuilleumier, 2012). The mean valence and arousal ratings (based on GEPED or IAPS scores) for the positive social–emotional scenes was: $V = 75.48$, SD = 11.17; $A = 39.38$, SD = 12.31. The mean valence and arousal ratings for the negative social–emotional scenes was: $V = 30.52$, SD = 16.01; $A = 56.09$, SD = 14.41.

2.5. Emotion attribution task

Immediately prior to MRI scanning, each participant completed a practice version of the emotion attribution task (Fig. 1). The practice version of the task was identical to the fMRI version of the task except for the use of different stimuli (target and cause) within the paradigm. Prior to the task each participant was read the following statement:

> *"We are interested in your ability to identify the cause of someone else's emotional response. In this experiment you will be presented photographs taken of people while they were presented images of social scenes. During this task, your job is to decide which of two pictures you believe each person was reacting to."*

Each participant was instructed to make two types of decisions, either emotion attribution or gender match. During the emotion attribution condition, each participant was instructed to decide which of the two social–emotional scenes (cause) they believed