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The correlation between Emotional Intelligence and gray matter volume in university students

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ABSTRACT

A number of recent studies have investigated the neurological substrates of Emotional Intelligence (EI), but none of them have considered the neural correlates of EI that are measured using the Schutte Self-Report Emotional Intelligence Scale (SSREIS). This scale was developed based on the EI model of Salovey and Mayer (1990). In the present study, SSREIS was adopted to estimate EI. Meanwhile, magnetic resonance imaging (MRI) and voxel-based morphometry (VBM) were used to evaluate the gray matter volume (GMV) of 328 university students. Results found positive correlations between Monitor of Emotions and VBM measurements in the insula and orbitofrontal cortex. In addition, Utilization of Emotions was positively correlated with the GMV in the parahippocampal gyrus, but was negatively correlated with the VBM measurements in the fusiform gyrus and middle temporal gyrus. Furthermore, Social Ability had volume correlates in the vermis. These findings indicate that the neural correlates of the EI model, which primarily focuses on the abilities of individuals to appraise and express emotions, can also regulate and utilize emotions to solve problems.

1. Introduction

As proposed by Salovey and Mayer in 1990, Emotional Intelligence (EI) represents the ability of an individual to manage and exploit his/her feelings and emotions to guide his/her thinking and actions (Salovey & Mayer, 1990). The publication of "Emotional Intelligence" by Goleman (1995) increased the public interest toward the applications and implications of EI over the past 20 years. Some researchers considered EI as a series of trait-like abilities that can be assessed by self-reporting (Bar-On, 2004), while other researchers argued that EI must be measured by demonstrable abilities in solving emotional problems (Mayer, Salovey, Caruso, & Sitarenios, 2002). Nevertheless, many studies had examined both trait and ability EI measures as valuable predictors of important outcomes for individuals, including social relationships, mental and physical health, work performance, and academic achievement (Brackett et al., 2013).

Studies on the neurological substrates of EI have begun to emerge recently. Two clinical studies reported that patients with lesions in the so-called somatic marker circuitry (SMC) or "body loop" exhibit a significantly lower EI than that of the control group (Bar-On, Tranel, Denburg, & Bechara, 2003; Krueger et al., 2009). The "body loop" was hypothesized to integrate the emotional signals originating from the body ("somatic markers"), with conscious cognitions to guide the decision-making process toward optimal outcomes (Damasio, Tranel, & Damasio, 1991). The circuitry covers several brain regions, including the amygdala, insular cortex, somatosensory cortex, and orbitofrontal (ventromedial prefrontal) cortex (Damasio, 1998). New techniques, such as MRI, have enabled non-invasive investigations into the human brain. For example, one functional MRI study corroborated the role of the "body loop" in EI (Killgore & Yurgelun-Todd, 2007). In addition, the researchers found that the activities of other brain regions, such as the middle temporal gyrus (MTG), occipital gyrus, fusiform, cuneus, precuneus, parahippocampus, and cerebellum, were related to EI when the subjects were asked to respond to a presentation of fearful faces.

Three structural brain imaging studies investigated the correlations between EI and the voxel-wise gray matter (GM) in the brain by VBM (Killgore et al., 2012; Koven, Roth, Garlinghouse, Flashman, & Saykin, 2010; Takeuchi et al., 2011), and all the results corroborated the role of SMC in individual EI. For example, Takeuchi et al.

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(2011) found that EI is associated with the GM density of the brain regions involved in SMC and in the social cognition network; Killgore et al. (2012) also supported the role of the ventromedial prefrontal cortex (VMPFC) and insula as key regions in the EI circuitry. However, several differences were detected in these three studies. Takeuchi et al. (2011) investigated the relationship between EI and gray matter density (GMD), whereas the other two structural imaging studies examined the relationship between EI and GMV, which may account for the discordance in the direction of their reported correlations. However, the relationship between GMD and GMV remains unclear. More importantly, the differences in the results may be due to the different EI scales that have been used in these studies and the relatively small sample that has been recruited. The utilized scales implicate different dimensions according to different EI models. The Emotional Intelligence Scale (EIS) that was used by Takeuchi et al. (2011) comprises three factors, namely, an intrapersonal factor, an interpersonal factor, and a situation management factor, which evaluate the ability of an individual to appraise as well as to cope with his/her self, with others, and with situations, based on the EI model of Bar-On (1997). However, the anatomy of the human brain may be structured according to different functions rather than according to intrapersonal and interpersonal abilities. The Trait Meta Mood Scale (TMMS) that was used by Koven et al. (2010) is capable of assessing EI, with specific attention given to emotions, clarity of emotions and mood repair. Attention to emotions measures the degree to which an individual pays attention to subjective feelings. Clarity of emotions measures the ability of an individual to perceive and understand subjective feelings. Lastly, mood repair measures the ability of an individual to manage emotions and repair negative feeling states (Koven et al., 2010). However, an increasing number of emotional theories claim that negative feelings are helpful and must not always be repaired (Ochsner, Silvers, & Buhle, 2012). The Bar-On Emotional Quotient Inventory (EQ-i) that was used by Killgore et al. (2012) is similar to EIS. The three previously mentioned scales are all trait measures that can be assessed by self-reporting. Killgore et al. (2012) also used the Mayer–Salovey–Caruso Emotional Intelligence Test (MSCEIT), which measures abilities based on the EI model of Mayer and Salovey (1997) and could yield an Experiential EI score as well as a Strategic EI score (Mayer & Salovey, 2007). Similar to the Monitor of Emotions aspect (see Emotional Intelligence Scale in Section 2) in the present study, Strategic EI indicates the ability of an individual to understand personal subjective feelings and those of others and to effectively regulate such feelings. Similar to the Utilization of Emotions aspect (see Emotional Intelligence Scale in Section 2) in this study, Experiential EI indicates the ability to discriminate personal emotions, those of others, and various inanimate stimuli as well as to use emotional information to facilitate problem-solving (Killgore et al., 2012). Killgore et al. (2012) only investigated the territory regions-of-interest (ROI) in the SMC, which was the potential cause of their failure in observing a correlation between GMV and Experiential EI. To the best of our knowledge, no study has yet examined the correlations between brain structure and trait EI assessed by the Schutte Self-Report Emotional Intelligence Scale (SSREIS), which includes specific EI abilities according to the theoretically cohesive and comprehensive EI model of Salovey and Mayer in 1990 (Schutte et al., 1998). The EI model focuses on the abilities of individuals to appraise and express emotions as well as to regulate and utilize emotions to solve their problems. These capabilities are widely accepted by the public and correspond to the basic capacities that can be mapped to the human brain (Salovey & Mayer, 1990). Although the process-oriented model of Mayer and Salovey (1997) was also revised. Schutte et al. (1998) argued that the original model developed in 1990 could better conceptualize the current state of EI development facets of an individual than the revised model. Most dimensions of the revised model can also be integrated into the original model.

Given that the three previously mentioned structural studies recruited relatively small samples and ignored the EI model of Salovey and Mayer (1990), the current study gathered a relatively large sample of local university students to evaluate the correlations between each dimension of the EI model and GMV. The VBM method was implemented to detect regional differences in GMV on a voxel basis across the entire brain (Mechelli, Price, Friston, & Ashburner, 2005). A Chinese version of the SSREIS was adopted, which included all four EI domains, namely, Monitor of Emotions (which means the ability to regulate effectively subjective emotions), Utilization of Emotions (which means the ability to utilize emotions in solving problems), Social Ability (which means the ability to use emotions in social activities), and Appraisal of Emotions in Others (which means the ability to appraise the emotions of others through verbal or non-verbal information) (Huang, Lu, Wang, & Shi, 2008).

In the light of the previous EI studies described earlier, especially the three structural studies, we predicted that volume correlates would appear in emotion-associated brain areas, including the VMPFC, somatosensory cortex, insular cortex, MTG, occipital gyrus, fusiform, cuneus, precuneus, hippocampus, parahippocampal gyrus (PHG), and cerebellum. We further hypothesized that the GMV correlates of Monitor of Emotions would comprise of regions within the SMC. Based on the results of Strategic EI studies, we expect these regions would include the VMPFC or orbitofrontal cortex (OFC), the insular cortex (Killgore et al., 2012), and an anatomical cluster that extends from the cuneus to the precuneus, which is a correlate of the Intrapersonal factor, as indicated in the study of Takeuchi et al. (2011). The Utilization of Emotions is expected to have a VBM correlate in the PHG, a region found to be correlated with emotional utilization in patients with early-stage schizophrenia (Wojtalik, Eack, & Keshavan, 2013). We also expected that the volume correlates of Utilization of Emotions would involve several regions in the temporal lobe because such regions were suggested to be related to emotional semantic coding and learning processes (Jefferies, 2012; Whitney, Kirk, O'Sullivan, Lambon Ralph, & Jefferies, 2010). We postulated that the volume correlates of Social Ability would include several regions of the "social brain", such as the adjacent anterior cingulate cortex, the temporoparietal junction (Amodio & Frith, 2006; Samson, Apperly, Chiavarino, & Humphreys, 2004), and the cerebellum, which was recently introduced in the "social brain" literature (Takeuchi et al., 2011). We also hypothesized that the GM correlates of the Appraisal of Emotions in Others aspect would emerge in the regions that were involved in social perception, such as the superior temporal sulcus, which was found to be correlated with the Interpersonal factor in the EI model of Bar-On (Takeuchi et al., 2011).

2. Methods

2.1. Subjects

A total of 335 right-handed, healthy volunteers from the local community of Southwest University in Chongqing participated in the study as part of our ongoing project to examine the associations between brain imaging, creativity and mental health. Participants were screened through a self-report questionnaire survey before the scanning to make sure of their healthy development. Thus, the participants who had a history of neurological or psychiatric illness, had received mental health care or had taken psychiatric medications were not included. Written informed consent was obtained from all participants prior to the experiment, in accordance with the Declaration of Helsinki (1991). This study