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The association between perceived social support and amygdala structure

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ABSTRACT

The subjective perception of social support plays a crucial role in human well-being. However, its structural neural substrates remain unknown. We hypothesized that the amygdala, specifically its laterobasal and superficial subregions, which have been suggested to serve social functions, could be associated with the level of perceived social support. To test this hypothesis, we assessed perceived social support using the Multidimensional Scale of Perceived Social Support. In addition, we measured the volume and shape of the amygdala using structural magnetic resonance imaging in 49 healthy participants. Global amygdala volume in the left hemisphere was positively associated with the perceived social support score after adjusting for total cerebral volume, sex, age, intelligence, and five-factor personality domains. The local shape of the laterobasal and superficial subregions of the left amygdala showed the same association with perceived social support. These data suggest that the social subregions of the left amygdala are associated with the implementation of perceived social support.

1. Introduction

The subjective perception of social support (i.e., the feeling of being supported by other people) plays an important role in human well-being (Lakey, 2014). Several previous psychological studies have shown that perceived social support is reliably linked to high life satisfaction, high positive affect, and low psychological distress (e.g., Diener and Fujita (1995); for a review, see Lakey (2014)). To investigate this important subjective construct, psychometric studies were undertaken, and several questionnaires were developed to measure perceived social support in a reliable and valid manner (e.g., Multidimensional Scale of Perceived Social Support [MSPSS]: Zimet et al. (1988); for a review, see López and Cooper (2011)). Although it intuitively appears that perceived social support is generated by actually being supported by other people, several previous studies consistently found that perceived social support was only mildly associated with receiving social support or with social network size (Barrera, 1986; Haber et al., 2007; Uchino, 2009). Moreover, several psychogenetic studies evaluating twins showed that perceived social support was substantially influenced by genetic factors (Bergeman et al., 1990; Kessler et al., 1992; Raynor et al., 2002) in contrast to social network size, which showed little genetic influence (Bergeman et al., 1990). Based on these data, it was proposed that perceived social support is not a state resulting from support received by a social network, but rather a stable characteristic similar to traits and personalities (Barrera, 1986; Lakey and Lutz, 1996; Uchino, 2009).

Despite such accumulating psychological evidence for perceived social support, the neural substrate that implements perceived social support remains largely unknown. Understanding the neural substrate of perceived social support may provide an objective measure of this subjective construct, which could complement its assessment theoretically (e.g., defense against skepticism for the validity of subjective measures; Oswald and Wu (2010)) and practically (e.g., assessment for participants with difficulty in subjective evaluation; Cummins (2014)). To date, only

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one previous magnetic resonance imaging (MRI) study has reported a structural neural substrate of perceived social support (Che et al., 2014a). In that study, the researchers assessed perceived social support using MSPSS (Zimet et al., 1988) and analyzed brain structures by conducting voxel-based morphometry. They found a positive association between the volume of the posterior cingulate cortex and the score of perceived social support, suggesting that this cortical region plays an important role in implementing the subjective perception of social support. However, because there are several different methods to analyze brain structures (e.g., delineation and volume measurement of the structures) with different advantages and disadvantages (Nemmi et al., 2015), exploration using different analysis methods may reveal the involvement of other brain regions in perceived social support.

A candidate brain region related to perceived social support is the amygdala. Ample evidence from lesion and recording studies in humans and monkeys indicates that the amygdala plays a key role in social function (e.g., Dicks et al. (1969); for reviews, see Adolphs (2010), Amaral (2003) and Kling and Brothers (1992)). A previous functional MRI study also reported that the association between amygdala activation in response to negative emotional facial expressions and anxiety was reduced by a higher level of perceived social support (Hyde et al., 2011). Several previous structural MRI studies that investigated the structural neural substrate of social network property, which is different from but mildly related to perceived social support as described above (e.g., Barrera (1986)), found positive relationships between social network size and amygdala volume (Bickart et al., 2011; Kanai et al., 2012; Von Der Heide et al., 2014).

No study has shown an association between amygdala structure and perceived social support. A previous study (Bickart et al., 2011) reported null findings regarding an association between amygdala volume and perceived social support using the Social Provisions Scale (Russell et al., 1984). However, we postulated that different measures with different advantages used to assess perceived social support (López and Cooper, 2011) might reveal the structural neural correlates. Whereas Che et al. (2014a) used voxel-based morphometry and did not find an association between amygdala volume and perceived social support, we postulated that a more in-depth analysis using a segmentation and measurement tool for the subcortical structures, such as the FMRIB's Integrated Registration and Segmentation Tool (FIRST) (Patenaude et al., 2011), could detect an association more sensitively. Therefore, we used a different scale and analysis method from the previous studies, and hypothesized that amygdala volume would be positively related to perceived social support.

Furthermore, we expected that specific subregions associated with perceived social support could be identified in the amygdala. Anatomical and physiological studies in animals have provided ample evidence that the amygdala consists of structurally and functionally distinct subregions, although the number and classification of subregions remain inconclusive (for a review, see Swanson and Petrovich (1998)). One of the dominant theories proposes that the human amygdala can be separated into three subregions: the laterobasal, superficial (cortical), and centromedial divisions (Heimer et al., 1999). Anatomical studies in animals have shown that these subregions have different cytoarchitectonic patterns in which the laterobasal and superficial subregions have cell types similar to those of the neocortex, while the centromedial subregion has neurons similar to those of the striatum (for a review, see McDonald (1998)). Animal studies also reported that these subregions have different connectivity patterns with other regions: the laterobasal-superficial subregions and the centromedial subregion comprise separate groups (for a review, see McDonald (1998)), and there are strong connections between the laterobasal group and frontotemporal system and between the centromedial subregion and autonomic system (for a review, see Swanson and Petrovich (1998)). This classification of amygdala subregions was implemented in probability maps in stereotaxic space in humans (Amunts et al., 2005), and some functional neuroimaging studies reported that emotional facial expressions specifically activated the laterobasal (Hurlemann et al., 2008) and superficial (Goossens et al., 2009; Hurlemann et al., 2008), but not the centromedial, subregions of the amygdala. These data suggest the possibility that the laterobasal and superficial subregions, compared with the centromedial subregion, might be more involved in social functioning. Consistent with this, a stereological study indicated that individuals with autism spectrum disorders (ASD), which are characterized primarily by qualitative impairments in social interaction (American Psychiatric Association, 2013), had fewer neurons in the laterobasal and superficial subregions but not in the centromedial subregion (Schumann and Amaral, 2006). Comparative anatomical studies also showed that the laterobasal and superficial, but not the centromedial, subregions of the amygdala have enlarged in an evolutionarily ascending order in primates (Barton and Aggleton, 2000; Stephan and Andy, 1977), especially in humans versus non-human primates (Barger et al., 2014; Barton and Aggleton, 2000), and hence some researchers suggested that these subregions may be related to the evolution of social functioning in primates (e.g., Barger et al. (2014)). Based on these data, we hypothesized that the enlargement of the laterobasal and superficial amygdala subregions might be specifically associated with a heightened perceived social support.

To test these hypotheses, we investigated the relationship between perceived social support and the global volume and local shape of the amygdala. We assessed perceived social support using the MSPSS (Zimet et al., 1988). To measure the volume and shape of the amygdala, we acquired structural MR images and delineated the bilateral amygdala using an automated method (Patenaude et al., 2011).

2. Materials and methods

2.1. Participants

The study included 49 Japanese volunteers (23 females; mean $\pm$ *SD* age, 22.4 $\pm$ 4.4 years). A psychiatrist or psychologist administered a short structured diagnostic interview using the Mini-International Neuropsychiatric Interview (Sheehan et al., 1998); no neuropsychiatric problem was detected in any participant. All participants were right-handed, as assessed by the Edinburgh Handedness Inventory (Oldfield, 1971). After the procedures were fully explained, all participants provided informed consent for participation. This study was approved by the local ethics committee of the Primate Research Institute, Kyoto University.

2.2. Psychological questionnaires

We used the Japanese version of the MSPSS (Zimet et al., 1988; Iwasa et al., 2007) to measure perceived social support. The questionnaire included 12 items that assessed perceived social support (e.g., "I get the emotional help and support I need from my family"). Four items comprised a subscale and measured perceived social support from three distinct sources: family, friends, and significant others (e.g., spouses; Zimet et al. (1990)). Each item was scored on a scale from 1 (very strongly disagree) to 7 (very strongly agree). The reliability and validity of the questionnaire were confirmed against the original (Zimet et al., 1988, 1990) and Japanese (Iwasa et al., 2007) versions.

We assessed the participants' personality domains to confirm that the results could not be accounted for by their basic personalities, not specific to perceived social support. We used the Japanese version of the NEO Five-Factor Inventory (Shimonaka et al., 1999), a 60-item self-rating questionnaire that measures the five domains of personality: neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness (12 items for each) (McCrae and Costa, 1987). The reliability and validity of the questionnaire have been verified in Japanese participants (Shimonaka et al., 1999).

We also assessed participants' intelligence quotients (IQs), because the subjective ratings can be confounded by intelligence (Cummins, 2014). We used the