



Abnormal degree centrality of functional hubs associated with negative coping in older Chinese adults who lost their only child



Wei Liu^{a,b,1}, Huijuan Liu^{a,b,1}, Dongtao Wei^{a,b}, Jiangzhou Sun^{a,b}, Junyi Yang^{a,b}, Jie Meng^{a,b}, Lihong Wang^c, Jiang Qiu^{a,b,*}

^a Key Laboratory of Cognition and Personality (SWU), Ministry of Education, Chongqing, China

^b Department of Psychology, Southwest University, Chongqing, China

^c Department of Psychiatry, University of Connecticut Health Center, Farmington, USA

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ABSTRACT

The loss of an only child is a negative life event and may potentially increase the risk of psychiatric disorders. However, the psychological consequences of the loss of an only child and the associated neural mechanisms remain largely unexplored. Degree centrality (DC), derived from resting-state functional magnetic resonance imaging (fMRI), was used to examine network communication in 22 older adults who lost their only child and 23 matched controls. The older adults who lost their only child exhibited an ineffective coping style. They also showed decreased distant and local DC in the precuneus and left inferior parietal lobule and decreased distant DC in the bilateral dorsolateral prefrontal cortex (DLPFC). Furthermore, the decreased local and distant DC of these regions and the decreased DLPFC-precuneus connectivity strength were negatively correlated with negative coping scores in the loss group but not in the controls. Overall, the results suggested a model that the impaired neural network communication of brain hubs within the default mode network (DMN) and central executive network (CEN) were associated with a negative coping style in older adults who lost their only child. The decreased connectivity of the hubs can be identified as a neural risk factor that is related to future psychopathology.

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1. Introduction

The one-child only policy, where only one child is allowed in each family, has been in place for more than 30 years in China (see Supplemental materials for history of the policy). While this policy has successfully controlled the rapid population growth rate in China, its associated problems and challenges for the Chinese government and citizens have also appeared. For example, parents with one child often become highly psychologically dependent on their only children, which is a unique parent–child attachment phenomenon. As a consequence, when a couple has lost their only child unexpectedly, it would have serious consequences for the entire family. The advent and expansion of “childless” older adults in China have become a significant burden to Chinese society. According to the Minister of Health in China, the number of families who lost their only child has risen to more than 1 million by 2011

(Health, 2010) and this figure is estimated to be 10 million by 2035 (J, 2012). The death of the only child can cause pronounced psychological consequences to their parents including long-term grief, depression, and anxiety (Li & Wu, 2013). Thus, it may become a significant and widespread public mental health problem with the increase in the number of the parents dealing with this type of life event.

There is abundant evidence in the literature supporting an association between the death of the loved one and a range of psychiatric disorders (e.g., depression, PTSD and substance use) (Brown, Stout, & Mueller, 1999; Bruce, Kim, Leaf, & Jacobs, 1990; Keyes et al., 2014; Zisook, Chentsova-Dutton, & Shuchter, 1998; Zisook & Shuchter, 1991). The couples who lost their only child at an older age are often devastated because of their inability to have another child. Therefore, they are at an extremely high risk of developing psychiatry disorders. Experiencing the death of a loved one may influence the risk of psychiatric disorders via a variety of cognitive, affective and neurobiological pathways (McEwen, 2012). Among them, individual differences in the stress response are a vital factor. Coping style, the behavioral pattern humans adopt when facing stress, is a psychological trait that can strongly affect how a stressful event is perceived and whether it can be effectively

* Corresponding author at: Department of Psychology, Southwest University, 2 Tiansheng Street, Beibei, Chongqing 400715, China.

E-mail address: qiu318@swu.edu.cn (J. Qiu).

¹ These authors contributed equally.

managed (Folkman, 1984). Evidence suggests that personal coping style is related to individual differences in stress-induced psychopathology (Billings & Moos, 1984; Folkman & Lazarus, 1980). However, the individuals' coping style after a particular major negative life event has not been studied in a highly homogeneous group. Data from older adults in China who have lost the only child is unique and valuable in this sense. We hypothesized that those who have lost an only child at an older age would exhibit an ineffective coping style.

Abnormal anatomical and functional connectivity of the brain hubs have been related to behavioral and cognitive impairment in neurological and psychiatric disorders (Crossley et al., 2014; van den Heuvel & Sporns, 2013). These brain regions are intensively connected with other nodes (Buckner et al., 2009; Tomasi, Shokri-Kojori, & Volkow, 2015; Tomasi & Volkow, 2010, 2011) and the functional hubs are largely overlapped with subregions of the default-mode network (DMN), a network related to self-related processes such as self-reference (Sheline et al., 2009), autobiographical memory (Spreng & Grady, 2010) and rumination (Hamilton et al., 2011). Impairments in these hubs have been found in previous studies as they are highly susceptible to disconnection and dysfunction caused by psychiatric disorders due to their high level of centrality. For example, the precuneus is implicated in depression (Bluhm et al., 2009a; Zhu et al., 2012), schizophrenia (Paulus et al., 2002; Whitfield-Gabrieli et al., 2009), post-traumatic stress disorder (PTSD) (Geuze, Vermetten, de Kloet, & Westenberg, 2007; Yan et al., 2013) and Alzheimer's disease (AD) (Ikonomic et al., 2011; Karas et al., 2007). The inferior parietal lobule (IPL), another hub within the DMN, shows abnormal DC in depression (Zhang et al., 2011) and an abnormal structure after stress exposure (Hanson et al., 2010). However, there are few studies that directly explore the functional connectivity of these brain hubs in individuals who are at a high risk for developing psychiatric disorders. The impairments may have happened before the onset of the clinical disorders and serve as the neural risk factors that contribute to future psychopathology. Therefore, we hypothesized that the older adults who lost their only child would exhibit reduced functional connectivity of these functional hubs, such as the precuneus and IPL or other brain regions, which, although not usually identified as brain hubs in previous studies, play a fundamental role in network communication. Additionally, these abnormalities may be associated with alterations of psychological variables.

In this preliminary study, every voxel was treated as an independent node and DC (Buckner et al., 2009; Sepulcre et al., 2010) was computed from this high-resolution functional brain network to map hubs in functional brain network and to identify the potential altered efficiency of any particular brain region after the death of an only child. We used DC to map the neural abnormality for two reasons. Firstly, the DC used in this study has been applied to mental disorders including the major depression disorder (Wang et al., 2014, 2015) schizophrenia (Tomasi & Volkow, 2014; Zhuo et al., 2014) and social anxiety disorder (Liu et al., 2015) and our major purpose is to investigate the risk for mental disorders. Secondly, DC is physiologically meaningful (Liang, Zou, He, & Yang, 2013; Tomasi, Wang, & Volkow, 2013) and can allow us to map the brain hubs with high sensitivity, specificity, and reproducibility (Tomasi et al., 2015). Therefore, DC is a better network parameters when compared to other measurements. Furthermore, we adopted an approach to capture the distant and local DC, respectively, using anatomical distance as a cutoff (Achard, Salvador, Whitcher, Suckling, & Bullmore, 2006; He, Chen, & Evans, 2008; Sepulcre et al., 2010). This method can allow us to investigate the local and distant brain interactions separately, which can explore the potential difference in the local and distant connectivity as a result of only child loss. Investigating the brain network abnormalities in older adults who lost their only child provides us an

opportunity to test the hypothesis that people who experienced severe life events may exhibit impaired connectivity of the brain hubs, and, therefore, they are at a high risk of developing psychiatric disorders. This situation may also allow us to identify the neural alterations in these individuals that precede the onset of mental illnesses.

2. Materials and methods

2.1. Participants

This study was approved by the Research Ethics Committee of the Brain Imaging Center of Southwest University. Informed consent was obtained from each subject before they participated in the study. We recruited 26 subjects reported the only child losing and finished the MRI scanning and the essential psychological measurements. Four subjects did not be included in this study because they also lost their spouse. All of the participants volunteered to complete the MRI scans, questionnaires, and interviews. Older adults who lost their only child (referred as the loss group below) were recruited from a local, government-supported organization in the Beibei district of Chongqing that aims to provide assistance to "the loss families". It is notable that no subjects had another child after the death of their only child. Controls were age, sex, educational attainment, and handedness matched parents who do not experience the loss of their only child or any other recent significant life events, including the death or severe illness of their spouse, close relatives or friends. All of the subjects in the control group are also the parents of the single child. A face-to-face interview was conducted to obtain the subjects' major life events (especially the information about the death of their only child) and current or lifetime diagnoses of psychiatric disorders was conducted using the semi-structured Traumatic Antecedents Interview (TAI) and the Structured Clinical Interview for DSM-IV Axis I and II Disorders (SCID-I and SCID-II) (First, Spitzer, Gibbon, & Williams, 2012). Before the experiment, we ruled out the individuals who are not suitable for scanning by face-to-face communication and the self-reported checklist. The MRI related exclusion criteria include claustrophobia, metallic implants, Meniere's Syndrome and history of faint within half of the year. Exclusion criteria for both groups were as follows: current psychiatric disorders and neurological disorders; use of any psychiatric drugs within the three months before scanning; substance abuse; and stroke or serious encephalopathy. Based on the exclusion criteria, 22 older adults in the loss group and 23 matched controls were included in this study. Only one subject in the loss group had a history of major depression disorder (10 months) and had recovered from it three years ago. Except for this subject, no one in the loss or control group had a history of any psychiatric disorders. Detailed demographic information is presented in Table 1.

2.2. Measures

Each participant was evaluated on their level of cognition, anxiety, depression, and stress coping skills using the Mini-Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975), Self-rating Anxiety Scale (SAS) (Zung, 1976), Self-Rating Depression Scale (SDS) (Zung, 1965), UCLA Loneliness Scale (Russell, 1996), Subjective Happiness Scale (SHS) (Lyubomirsky & Lepper, 1999), Social Support Rating Scale (SSRS) (Xiao and Yang, 1987) and Simplified Coping Style Questionnaire (SCSQ) (Xie, 1999). The MMSE was used to screen subjects with potential dementia; the SAS, SDS, SHS, SSRS, and the UCLA Loneliness Scale were used to measure the anxiety, depression, subjective happiness, social support, and the loneliness level of participants respectively. SCSQ is a tool for

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