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The neural substrates of procrastination: A voxel-based morphometry study

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ABSTRACT

Procrastination is a pervasive phenomenon across different cultures and brings about lots of serious consequences, including performance, subjective well-being, and even public policy. However, little is known about the neural substrates of procrastination. In order to shed light upon this question, we investigated the neuroanatomical substrates of procrastination across two independent samples using voxel-based morphometry (VBM) method. The whole-brain analysis showed procrastination was positively correlated with the gray matter (GM) volume of clusters in the parahippocampal gyrus (PHG) and the orbital frontal cortex (OFC), while negatively correlated with the GM volume of clusters in the inferior frontal gyrus (IFG) and the middle frontal gyrus (MFG) in sample one (151 participants). We further conducted a verification procedure on another sample (108 participants) using region-of-interest analysis to examine the reliability of these results. Results showed procrastination can be predicted by the GM volume of the OFC and the MFG. The present findings suggest that the MFG and OFC, which are the key regions of self-control and emotion regulation, may play an important role in procrastination.

1. Introduction

Procrastination is a pervasive phenomenon that has been investigated across different life domains, such as academic (Michinov, Brunot, Le Bohec, Juhel, & Delaval, 2011; Tan et al., 2008), work (Beheshtifar, Mazrae-Sefidi, & Moghadam, 2011), and health (Sirois, Melia-Gordon, & Pychyl, 2003). Procrastination, which is often established as a stable trait, refers to voluntarily delaying an important activity despite expecting to the negative outcomes (Ferrari, 2004; Klingsieck, 2013; Rozental & Carlbring, 2014; Sirois, 2014b). It has been estimated that about 70–80% of college students are engaged in procrastination, and almost 20% do so consistently and problematically (Esteban & Ramírez, 2014). Many studies have associated procrastination to negative life events, such as lack of retirement savings (O'Donoghue & Rabin, 1997), acute health problems (Sirois, 2004), and even destructive influence to national policies (Lynch & Zauberman, 2006). In an attempt to understand the nature of procrastination, a lot of researchers have focused on the reasons, influencing factors, and treatment of procrastination over the last few decades (Klingsieck, 2013; Rozental & Carlbring, 2014; Steel, 2007; Sirois & Pychyl, 2016a,b). However, it is worth noting that little is known about the neural substrates of procrastination.

1.1. Procrastination and Self-control

In view of behavioral studies in exploring the causes of procrastination, a few of studies have demonstrated that people experience self-control problems when they procrastinate (Burger, Charness, & Lynham, 2008). Flett, Blankstein, and Martin (1995) employed a measure of dispositional self-control and found that procrastinators tended to have a low score on it (thus reflecting poor self-control). Ferrari and Emmons (1995) also found that some people frequently procrastinated tasks because they were unable to control their desire for short-term pleasurable activities. And a strong negative correlation between self-control and procrastination at −0.58 has been found in a meta-analysis (Steel, 2007). Some studies also found that procrastinators preferred immediate over future rewards in intertemporal choices (Wu et al., 2016). And Eerde (2003)'s meta-analysis argued that the tendency for procrastination might be attributed to the inability to delay gratification, which indicated a lower ability to refrain from acting on undesired behavioral tendencies (Mancuso, 1981). It was indicated that subcomponents of executive functioning (such as self-monitor, working memory, and planning) were significant predictors of academic procrastination by investigating the effect of executive functioning on academic procrastination among college students (Rabin, Fogel, & Nutter-Upham, 2011). Another study using behavioral genetic methodology demonstrated that procrastinators exhibited lower

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executive abilities compared with the nonprocrastinators (Gustavson, Miyake, Hewitt, & Friedman, 2015). It seems that self-control or inhibiting distraction is one of the basic abilities needed to take the immediate action.

1.2. Procrastination and emotion regulation

It has been suggested that trait procrastination is a form of self-regulation failure (Klingsieck, 2013; Rozental & Carlbring, 2014; Steel, 2007; Steel & Klingsieck, 2015; Sirois & Pychyl, 2016a,b). Procrastination occurs most often when people are faced with a task that is viewed as aversive, and therefore it will lead to unpleasant feelings or negative mood. We think it is quite clear that this self-regulation failure has a great deal to do with short-term mood repair and emotion regulation. Yet researches to date have seldom shed light upon the nature of the association between procrastination and emotion regulation. It was demonstrated that a poor mood might not only result from procrastination but also create it (Lindsley, Brass, & Thomas, 1995). And choosing to voluntarily delay regardless of our intention was often associated with bad emotional states (e.g. anxiety, depression, and worry) (Eerde, 2003; Stöber & Joormann, 2001). Consequently, we gave in to feel good when we prioritized short-term mood repair in the fashion of procrastination (Tice & Baumeister, 1997). As was reviewed by Sirois and Pychyl (2013a), procrastination tended to occur for tasks with distal rewards or that were unpleasant, challenging, or humdrum and therefore eliciting negative emotions. To repair the current mood, people would exhibit the avoidance of the present task and replaced it with more pleasurable and enjoyable one. Hence, the temporal aspects of procrastination were so evident that the present self chose to delay a task in favor of the future self taking on this task later (Blouin-Hudon & Pychyl, 2015). A meta-analysis conducted by Sirois (2014b) also demonstrated that trait procrastination was indeed associated with less focus on the future and more focus on the present. In addition, it was necessary to exert the self-control to be engaged in the present task (Tice & Bratslavsky, 2000). Taken together, the ability of self-control and the negative emotional regulation should be concerned when we study the procrastination.

1.3. The neuroimaging studies

Previous studies provided compelling evidences to confirm how procrastination influenced our behaviors (Anderson & Block, 2010; D'Abate & Eddy, 2010), but little is known about the neural correlates of procrastination. Neuroimaging studies demonstrated strong associations between trait-oriented procrastination and brain regions which were central parts in the process of cognitive control and affective processing (Miller & Cohen, 2001). Using resting-state functional magnetic resonance imaging (rs-fMRI) technology, Zhang, Wang, and Feng (2016) found that procrastination could be attributed to hyperactivity of the default mode network (DMN) and the failure of top-down control exerted by the aPFC on the DMN. Another rs-fMRI study also found the activity of ventromedial prefrontal cortex (vmPFC) and ventrolateral prefrontal cortex (VLPFC) were negatively correlated with the level of procrastination (Wu, Li, Yuan, & Tian, 2016). Moreover, event-related potential (ERP) study was performed to demonstrate that high procrastinators exhibited a larger and delayed P_2 component which indicated that they preferred the immediate reward (Wu et al., 2016). Although the relationships between the procrastination and the underlying neural substrates have been explored, the neural structural underpinnings of procrastination still remains unclear. Given that procrastination is regarded as a trait which can be predicted by brain anatomy (Ashburner & Friston, 2000; J & KJ, 2001), it is reliable to explore the neural substrates of it by using voxel-based morphometry (VBM). In order to better understand procrastination, it is ponderable to investigate the brain structural basis of procrastination.

1.4. The present study

In present study, voxel-based morphometry (VBM) method was conducted to investigate neuroanatomical basis of procrastination. Many automated and objective MRI methods, including T1-weighted structural imaging and diffusion tensor imaging (DTI), have been used to characterize the healthy brain structural patterns, (Hoekzema et al., 2017; MF & JK, 2008). Remarkably, grey matter volume can be inspected and further calculated by voxel-based morphometry (VBM) analysis and it is an unbiased objective technique for characterizing anatomical differences throughout the brain (Ashburner & Friston, 2000; J & KJ, 2001). An increasing body of researches have demonstrated that individual differences in diverse cognitive ability and personality can be reliably inferred from neuroanatomical structure (Kanai & Rees, 2011a; Wang et al., 2016; Yang et al., 2017; Zhang, Li, et al., 2016). In the present study, we employed voxel-based morphometry (VBM) method to explore neural substrates of procrastination across two independent samples. Firstly, we performed the whole-brain VBM analysis to identify the neural correlates of procrastination that was quantified by general procrastination scale (GPS) for sample 1. Then, another independent sample (sample 2, 108 participants) was used to test the reliability of the results found in sample 1. For sample 2, we defined brain regions that significantly correlated with procrastination as regions of interest (ROIs) from sample 1, and examined whether the GM volume of these ROIs could predict procrastination.

2. Methods

2.1. Participants

Sample 1 consisted of 151 healthy participants (male: 99, female : 52, age : 17–25 years old, mean age : 19.85 ± 1.60) from Southwest University (China). Sample 2 consisted of 108 participants (male: 45, female: 63, age: 17–25 years, mean age: 20.47 ± 1.85) coming from a same population, but was independent from the participants of Sample 1 and the subjects of two samples participated the experiment at different times. The study was approved by the Ethics Committee of Southwest University, and all participants were given informed consent. All participants had no history of psychiatric disorders or any neurological illnesses and were paid 60 RMB for their participation.

2.2. Measurement of procrastination

Procrastination was assessed by the General Procrastination Scale (GPS) which was designed by Lay (1986). The GPS was used frequently to measure procrastination (Dewitte & Lens, 2010; Gupta, Hershey, & Gaur, 2012; Gustavson, Miyake, Hewitt, & Friedman, 2014; Sirois, 2004). It contains 20 items (e.g., “I generally delay before starting on work I have to do” and “I often find myself performing tasks that I had intended to do days before”) and participants rated themselves from “extremely uncharacteristic” to “extremely characteristic” with one to five. This scale is unidimensional and its higher total scores indicate the higher tendency of procrastination. It was reported that the cronbach’s alpha coefficient was 0.82 (Lay, 1986). Especially the GPS was turned out to be a good reliability in the behavioral genetic methodological study finding the heritability of procrastination. Furthermore, previous studies have demonstrated that the reliability and validity of GPS were acceptable both in western (Grund & Fries, 2018; Nikcevic, Hiou, & Spada, 2006) and Chinese settings (Chu, Xiao, & Lin, 2010; Hu, Chen, & Cai, 2012). In our study, the reliability of the GPS was assessed by coefficient Cronbach’s alpha in the two samples, and both of reliability are more than 0.82 (Cronbach’s alpha coefficient = 0.873, 0.843, respectively). It indicated that the reliability of GPS in our study was acceptable (Aiken, 1997). The two samples are both normally distributed by One-Sample Kolmogorov-Smirnov Test.