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# THE OVERLAPPING BRAIN REGION ACCOUNTING FOR THE RELATIONSHIP BETWEEN PROCRASTINATION AND IMPULSIVITY: A VOXEL-BASED MORPHOMETRY STUDY

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**Abstract—Procrastination is a prevalent problematic behavior that brings serious consequences, such as lower levels of health, wealth, and well-being. Previous research has verified that impulsivity is one of the traits most strongly correlated with procrastination. However, little is known about why there is a tight behavioral relationship between them. To address this question, we used voxel-based morphometry (VBM) to explore the common neural substrates between procrastination and impulsivity. In line with previous findings, the behavioral results showed a strong behavioral correlation between procrastination and impulsivity. Neuroimaging results showed impulsivity and procrastination shared the common neurobiological underpinnings in the dorsolateral prefrontal cortex (DLPFC) based on the data from 85 participants (sample 1). Furthermore, the mediation analysis revealed that impulsivity mediated the impact of gray matter (GM) volumes of this overlapping region in the DLPFC on procrastination on another independent 84 participants' data (sample 2). In conclusion, the overlapping brain region in the DLPFC would be responsible for the close relationship between procrastination and impulsivity. As a whole, the present study extends our knowledge on procrastination, and provides a novel perspective to explain the tight impulsivity – procrastination relationship. © 2017 Published by Elsevier Ltd on behalf of IBRO.**

**Key words: procrastination, impulsivity, voxel-based morphometry.**

## INTRODUCTION

Procrastination is a widespread phenomenon (Kachgal et al., 2001; Steel, 2007). Approximately 15–20% adults are classified as chronic procrastinators (Harriott et al., 1996). Procrastination, as Steel (2007) reviewed, is the phenomenon that individuals are "to voluntarily delay an intended course of action despite expecting to be worse off for the delay". As a result, this self-regulatory failure leads procrastinators to have lower levels of health, wealth, and well-being (Sirois, 2004; Steel, 2007). Impulsivity is a predisposition toward rash, unplanned reactions to stimuli regardless of the negative consequences of these reactions to impulsive individuals or to others (Fischer et al., 2008; Moeller et al., 2001). It has been found that impulsivity is one of the traits most strongly correlated with procrastination, moderately correlated with procrastination at 0.41 in a meta-analysis research (Steel, 2007). Some studies also found that procrastinators prefer immediate over future rewards in intertemporal choices (Wu et al., 2016a) and are incompetent to delay gratification (Van Eerde, 2003), which indicates a high level of impulsivity of them (Steel and König, 2006). However, little is known about the neural substrates underlying the relationship between procrastination and impulsivity.

This high correlation could be attributed to the shortage of self-control ability. Self-control was the ability to override or change one's inner responses, as well as to interrupt undesired behavioral tendencies (such as impulses) and refrain from acting on them (Carver and Scheier, 2012; Tangney et al., 2004). Facing with the long-term goals, procrastinators frequently put off work to meet short-term benefits (Steel, 2007; Steel and Klingsieck, 2016). These short-sighted behaviors are attributed to the deficiency of self-control ability. Individuals lacking self-control ability are unable to suppress the desire for immediate or enjoyable temptation (Ferrari and Emmons, 1995; Pychyl et al., 2000). Also, some studies have shown that the self-control ability has a close association with impulsivity (Baumeister, 2002; Spinella, 2004). Loss of control makes people fail to resist impulsive behaviors, for instance drug abuse (Bechara, 2005; Bickel et al., 2012), impulsive buying (Rose, 2007; Vohs and Faber, 2007), and alcoholic dependence (Fox et al., 2008). Thus, this self-control ability facilitating long-term goals should be highlighted as a core component to understand the close impulsivity–procrastination relationship.

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*Abbreviations:* ACC, anterior cingulate cortex; DLPFC, dorsolateral prefrontal cortex; GM, gray matter; mPFC, medial prefrontal cortex; OFC, orbitofrontal cortex; VBM, voxel-based morphometry; vmPFC, ventromedial prefrontal cortex.

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Furthermore, some empirical studies have been carried out using behavioral genetic methodology. It has been found that procrastination and impulsivity share considerable genetic variation (1.0), and variation in goal-management ability accounts for much of this shared genetic variation (Gustavson et al., 2014). Though other researchers who collect larger twin samples in Australia have found that the genetic correlation between impulsivity and procrastination is really at about 0.3 (or 0.2) than 1.0 (Loehlin and Martin, 2014), this close genetic relationship cannot be ignored. Furthermore, some goal-management ability training studies show that individuals will devote themselves more to goal-oriented behavior if inhibition and control ability are improved by listing and monitoring subgoals (Levine et al., 2000), and using periodic auditory alerts (Manly et al., 2002). It seems that self-control or inhibiting distraction is one of the basic abilities needed to improve goal-management ability. Thus, the self-control ability may account for the impulsivity–procrastination relationship. In this study, we used voxel-based morphometry (VBM) to compare the brain structure correlated with procrastination to that of impulsivity.

It is worthy to pay more attention to the prefrontal region which is a core part in the process of cognitive control or self-control (Miller, 2000). A study has found that when dieters control themselves to make long-sighted decisions of rejecting most taste good-but-unhealthy food, there will be greater activity in ventromedial prefrontal cortex (vmPFC) and dorsolateral prefrontal cortex (DLPFC) (Hare et al., 2009). On the contrary, if individuals have lower control ability of suppressing food taste or appetite, they will be more likely to become obese and have smaller gray matter (GM) volumes in the DLPFC (Pannacciulli et al., 2006; Brooks et al., 2013). In addition, transient disruption in lateral prefrontal cortex (LPFC) by low-frequency repetitive transcranial magnetic stimulation (rTMS) triggers increasing preference for immediately available rewards in intertemporal choice (Figner et al., 2010). Some morphology studies have shown that these impatient behaviors are associated with smaller GM volume in the LPFC (Bjork et al., 2009) and medial prefrontal cortex (mPFC) (Cho et al., 2013). Similarly, procrastinators and impulsive individuals also need the self-control ability to make a rational choice regardless of desirable temptation (Steel, 2007). Furthermore, the VBM study has found that small orbitofrontal cortex (OFC) and anterior cingulate cortex (ACC) volume are related to high impulsivity (Matsuo et al., 2009). However, as far as I know, there is little VBM study about procrastination. The mere rest-state fMRI study indicates that procrastination has a close relationship with DLPFC (Zhang et al., 2016), vmPFC and ventral lateral prefrontal cortex (Wu et al., 2016b). Taken all together, we predicted that both the impulsivity and procrastination would be inversely correlated with the GM volumes of some similar regions in the prefrontal cortex.

In the present study, we employed VBM to explore neural substrate clues responsible for the tight behavioral relationship between impulsivity and procrastination. First, in sample 1, we used the General procrastination scale and the Barratt impulsiveness scale to assess individuals' level of procrastination and impulsivity, respectively. Then, to identify the neural substrates responsible for their relationship, we performed the whole-brain VBM analysis to detect and compare regional GM volumes correlated with impulsivity and procrastination in sample 1 as well. Finally, in order to explore the role of GM volumes in regions emerging from whole-brain analysis above on the relationship between impulsivity and procrastination, and examine the reliability of the results above as well, we extracted the GM volumes of the overlapping brain region on another group of participants (sample 2). Subsequently, a mediation analysis was performed among the GM volumes of the related brain region, impulsivity and procrastination.

## EXPERIMENTAL PROCEDURES

### Participants

Sample 1 consisted of 85 healthy college students (55 women; $M = 20.53$ years, $SD = 2.07$ years) from Southwest University (China). Sample 2 consisted of 84 healthy college students (51 women; $M = 19.51$ years, $SD = 1.35$ years) from the same population, but was independent from the participants of sample 1. All of the participants were right-handed and had normal or corrected-to-normal vision. None had a history of neurological or psychiatric disorder. All participants volunteered to participate in this study and were given informed consent prior to the participation. The study was approved by the Institutional Review Board of the Southwest University. After the experiment, all participants were compensated with some payments.

### Measures

*Procrastination.* Levels of procrastination are assessed with General procrastination scale (Lay, 1986), which is used most often to measure procrastination (Dewitte and Lens, 2000; Gustavson et al., 2014; Spada et al., 2006). The scale includes 20 items, and have 5-point Likert-type response format ranging from 1 (strongly disagree) to 5 (strongly agree). This scale is unidimensional and its total scores are used as the indicator of participants' level of procrastination (Howell et al., 2006; Pychyl et al., 2000). Higher scores indicate high tendency of procrastination. It has been reported that Cronbach's alpha coefficient is 0.82 (Lay, 1986). In this study, reliability in sample 1 and sample 2 are adequate (Cronbach's alpha coefficient = 0.898, 0.838, respectively).

*Impulsivity.* The Barratt impulsiveness scale version 11 (BIS-11) (Patton et al., 1995) is a 30-item self-report questionnaire designed to assess individual's impulsive traits. All items are answered using a 4-point Likert-type response format (Rarely/Never, Occasionally, Often, Almost Always/Always). The BIS has three subscales: attention (rapid shifts and impatience with complexity), motor (impetuous action) and nonplanning (lack of future

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