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The procrastinators want it now: Behavioral and event-related potential evidence of the procrastination of intertemporal choices

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ABSTRACT

Much past research has focused on the correlation between procrastination and personality traits (e.g., impulsivity). According to the temporal motivation theory, procrastinators are impulsive and sensitive to delays in time. However, there is still a lack of direct evidence of the tendency of procrastinators to prefer immediate over future rewards. To investigate this question, we recorded event-related potentials (ERPs) in the brain while participants performed an intertemporal choice task involving both time delay and reward processing. The participants were assigned to a high procrastination group and a low procrastination group according to their scores on self-report measures. We found that high procrastination participants preferred immediate rewards compared to future ones whereas low procrastination participants did not. High procrastinators also exhibited a larger and delayed P2 component, indicating delay time processing and abnormal reward processing. No significant effect associated with procrastination was found on the P300 component. Taken together, these findings suggest that high procrastinators are more impulsive and encode the information of delay time more slowly but with a higher level of motivation-driven attention. The current study substantiates higher impulsivity in procrastination and verifies that a difference exists in the sensitivity to time delay between high and low procrastinators.

1. Introduction

Procrastination is a prevalent phenomenon that widely occurs not only in students (e.g., academic procrastination) but also in adults (Ellis & Knaus, 1977; Harriott & Ferrari, 1996; Lavoie & Pychyl, 2001; Rothblum, Solomon, & Murakami, 1986; Steel & Ferrari, 2013). According to the definition proposed by Steel, procrastination describes the irrational delay of an intended course of action despite the negative consequences (Steel, 2007, 2010). Many previous studies have reported various factors that modulate procrastination and/or the consequences of procrastination (Beswick, Rothblum, & Mann, 1988; Ferrari, Harriott, & Zimmerman, 1999; Lay, Edwards, Parker, & Endler, 1989; Steel, Brothen, & Wambach, 2001; Stober & Joormann, 2001). For instance, when considering procrastination as a personality trait, its level is negatively correlated with conscientiousness (Johnson & Bloom, 1995). Environmental factors, such as social networks (Ferrari et al., 1999), parenting styles (Milgram, Mey-Tal, & Levison, 1998; Pychyl, Coplan, & Reid, 2002), and task designs (Milgram, Marshevsky, & Sadeh, 1995) also influence the tendency to procrastinate. However, many aspects of procrastination are still unclear to researchers, especially the cognitive characteristics of procrastinators, such as their time perception and reward processing.

It is noteworthy that many theories and studies propose that procrastination is linked to impulsivity. For example, van Eerde (2003) argued that the tendency for procrastination may be attributed to an inability to delay gratification, which is associated with a lack of impulse control. In line with this hypothesis, the temporal motivation theory (TMT; Steel & König, 2006), which was derived from the expectancy theory and hyperbolic discounting, considers the sensitivity to time delay to be an important element in the motivation utility equation (Steel, 2007). Specifically, the utility equation is composed of four components: the numerators are expectancy (E) and value (V), the denominator is immediately realizable (D), and Γ refers to the person's sensitivity to time delay.

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According to this equation, as the length of time delay increases, utility consequently shrinks (Steel, 2010). Distractibility, impulsiveness, and lack of self-control are closely related to the sensitivity to delay (Γ). As such, procrastinators are supposed to be more impulsive and sensitive to delays in time than people who procrastinate less often.

The role of time sensitivity in the tendency for procrastination has been partly confirmed, as self-report data suggests that people with higher levels of procrastination are more concerned with the present than the future (Díaz-Morales, Ferrari, & Cohen, 2008; Ferrari & Diaz-Morales, 2007; Sirois, 2014). Furthermore, researchers have proposed that procrastination is related to impulsivity (Steel, 2007). A recent study has investigated the genetic correlation between procrastination and impulsivity using a behavioral-genetic analysis method, the results of which indicated that both procrastination and impulsivity were moderately heritable, with the two being linked primarily through genetic influences (Gustavson, Miyake, Hewitt, & Friedman, 2014). Such findings confirmed a link between impulsivity and procrastination. However, much is yet unknown *about whether procrastinators show more impulsive behaviors, due to the lack of direct experimental evidence*.

Various ways of measuring impulsivity have been developed to investigate the mechanism of impulsivity. One important method is using a self-assessment impulsivity scale, such as the Barratt Impulsivity Scale (BIS; Barratt & Patton, 1983). Another way to measure impulsivity is laboratory experimental tasks such as intertemporal choices and delayed discounting of reward (Basar et al., 2010). Intertemporal choices are decisions with consequences that play out over time, in which people make a trade-off between outcomes occurring at different time points (Berns, Laibson, & Loewenstein, 2007; Frederick, Loewenstein, & O'Donoghue, 2002). Typically, intertemporal choices involve a choice between a smaller, more immediate reward and a larger, more delayed reward (Green & Myerson, 2004), and people are considered as impulsive (i.e., higher time discounting) if they prefer the immediate smaller reward over the larger delayed reward (Green & Myerson, 2004; Wittmann & Paulus, 2008). Given the time perspective of procrastination and the connection between procrastination and impulsivity, we expect that procrastination would be associated with behavioral performance in an intertemporal choice task, such that the tendency to choose increases as a function of the level of procrastination. In addition, the intertemporal choice task design integrates the factor of delay time processing, which is a key component in the TMT (i.e., the sensitivity to time delay). Therefore, we believe that an intertemporal choice task is well suited for confirming the TMT of procrastination.

Neuroscience methods, such as brain-imaging techniques and event-related potentials (ERPs), could help to understand the neural mechanisms of the impact of procrastination on intertemporal choices. In the past decade, several brain-imaging studies using intertemporal choice tasks have revealed that the limbic system (including the ventral striatum) and the executive function system (including the lateral and medial prefrontal cortex) are involved in intertemporal decision making (Albrecht, Volz, Sutter, Laibson, & von Cramon, 2011; Bickel, Pitcock, Yi, & Angtuaco, 2009; Figner et al., 2010; Kable & Glimcher, 2007; Takahashi et al., 2009). In contrast, despite the high temporal resolution of the ERP technique, to our knowledge there have been few attempts to combine it with intertemporal choice tasks (Cherniawsky & Holroyd, 2013; Li et al., 2012; Oswald & Sailer, 2013). However, one recent work has found that the P2 reflects the temporal distance effect (He, Huang, Yuan, & Chen, 2012). Another ERP work has suggested that participants preferring an immediate reward exhibit larger P2 and P300 components in an intertemporal choice task (Li et al., 2012). Thus, we considered the P2 and P300 to be candidate ERP components in the present task.

The P2 has been viewed as an index of attention and several studies have reported a delayed and increased P2 in elderly people (Crowley, Trinder, & Colrain, 2002; Pfefferbaum, Ford, Wenegrat, Roth, & Kopell, 1984). This change in P2 is considered to reflect a deficit in the capacity to withdraw attentional resources from stimuli (Garcialarrea, Lukaszewicz, & Mauguiere, 1992). Furthermore, the P2 is larger in amplitude during auditory stimulus processing (Pfefferbaum, Ford, Roth, & Kopell, 1980) and the Go/No-Go sustained attention task (Finnigan, O'Connell, Cummins, Broughton, & Robertson, 2011) in elderly individuals. Notably, a number of studies have indicated that the P2 is also modulated by motivational relevance or affective significance (Carretie, Hinojosa, Martin-Loeches, Mercado, & Tapia, 2004; Carretie, Martin-Loeches, Hinojosa, & Mercado, 2001; Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000). Therefore, a difference of P2 amplitude among procrastinators in an intertemporal choice task might indicate deficits in attentional or motivational components of intertemporal decision making.

Another candidate ERP component is the P300, which is a late positive component that is more positive following a salient stimulus, such as a stimulus with low probability (Sugg & Polich, 1995), a criminal-related stimulus (Farwell & Donchin, 1991; Rosenfeld, Nasman, Whalen, Cantwell, & Mazzeri, 1987), or a larger reward magnitude outcome (Sato et al., 2005; Yeung & Sanfey, 2004). Previous studies have also shown an impulsivity-related effect on the P300 amplitude (Harmon-Jones, Barratt, & Wigg, 1997; Martin & Potts, 2004, 2009). Therefore, we expected the P300 to show a reward magnitude effect in the present study, which might be sensitive to procrastination.

The stimuli used in previous studies with intertemporal choice tasks were relatively complicated, which made it difficult to build a time-locked relationship between stimuli processing and ERP components, and to disassociate delay time perception and reward processing. Specifically, classic intertemporal choice tasks show the time information and reward information on the screen simultaneously; therefore, they are unlikely to discriminate the time-related ERP responses from those associated with reward-related processing. The current task design separated the time delay dimension from the reward dimension of options to dissociate delay time processing and reward processing. As stated above, previous studies have shown that procrastinators are more concerned with the present than with the future. To focus on this hypothesis, and to simplify the design of the experimental conditions in the present task, we asked participants to choose between an amount of money in the present (50 yuan) or more money after a certain time delay. Following the TMT, we predicted that: (1) high procrastination participants will choose more "present" options, since they are more impulsive; (2) high procrastination participants will allocate more attentional resources to the delay time, which will be reflected by a larger P2; and (3) there will be a difference between high and low procrastination participants in future reward sensitivity, which may be reflected in the P300. Overall, procrastinators may prefer an immediate reward and pay more attention (a larger P2) to the present than the future, since they have stronger time delay sensitivity and impulsivity.

2. Method

2.1. Participants

Forty-seven participants (23 female, 24 male; $M = 21.98$ years old, $SD = 2.5$) were recruited from several universities of Beijing. All participants were paid (50 yuan, see below) and signed a written informed consent form. The study was conducted in