

Cognitive Neuroscience Models of Procrastination and Interventions

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Abstract

Procrastination is a ubiquitous problem behavior characterized by cross-temporal and cross-situational stability that compromises individuals' learning, work performance, and physical and mental well-being. However, the cognitive-neural mechanisms underlying procrastination remain poorly understood, and causal evidence is lacking. The present project proposes to construct a cognitive-neural model of procrastination grounded in the temporal decision-making model and the triple neural structural network model of procrastination, and to test and refine this model using cognitive intervention and neuromodulation techniques, ultimately aiming to develop a precision intervention protocol. The project comprises three components: (1) From a recording and correlational research perspective, systematically investigating the cognitive-neural mechanisms of procrastination through multimodal neuroimaging methodologies; (2) From a causal/near-causal research perspective, validating and improving the cognitive-neural model via cognitive intervention and neuromodulation techniques; and (3) From a clinical application perspective, establishing a clinical screening-diagnostic system for procrastination behavior disorder and formulating precision treatment protocols. This project will yield significant theoretical contributions to elucidating the core cognitive-neural mechanisms of procrastination, while holding important practical implications for the effective prevention and precision treatment of procrastination behavior.

Full Text

The Cognitive Neural Model of Procrastination and Interventions

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Abstract

Procrastination is a widespread problematic behavior that exhibits stability across time and situations, harming individuals' learning, work, and physical and mental health. However, the cognitive neural mechanisms underlying procrastination remain unclear and lack causal evidence. This project aims to construct a cognitive neural model of procrastination based on the time decision model and triple neural structure network model, using cognitive interventions and neural regulation techniques to test and refine this model, and thereby develop precision intervention protocols. The project comprises three components: (1) From a recording and association research perspective, using multimodal neuroimaging methods to systematically investigate the cognitive neural mechanisms of procrastination; (2) From a causal/near-causal research perspective, using cognitive interventions and neural regulation techniques to validate and improve the cognitive neural model of procrastination; and (3) From a clinical application perspective, establishing a clinical screening-diagnosis system for procrastination behavior disorder and developing precision treatment protocols. This project will make important theoretical contributions to elucidating the core cognitive neural mechanisms of procrastination and holds significant practical value for the effective prevention and precise treatment of procrastination behavior.

Keywords: procrastination, cognitive neural model, cognitive intervention, neuro-regulation

1. Problem Statement

“Tomorrow after tomorrow, how many tomorrows there be; if all my life awaits tomorrow, all things will come to naught.” This poem from the *Song of Tomorrow* captures the perils of procrastination and warns against its dangers. Procrastination refers to the voluntary delay in starting or completing a planned task despite anticipating negative consequences (Steel, 2007). Research across different cultural contexts consistently demonstrates that procrastination is prevalent across populations: 15%-20% of adults experience chronic procrastination (Ferrari et al, 2005), over 70% of students acknowledge academic procrastination (Ferrari et al, 1995), and severe academic procrastination affects approximately 16% of students (Li et al, 2021). Numerous studies confirm that procrastination not only impairs academic performance and work achievement (Kim & Seo, 2015; Steel & Ferrari, 2013) but also generates intense negative emotions such as anxiety, self-blame, and self-doubt (Sirois, 2014), ultimately harming physical and mental health by exacerbating cardiovascular disease and compromising immune function (Sirois, 2015). Therefore, identifying the core mechanisms underlying procrastination and developing effective clinical interventions represent critical concerns for researchers worldwide.

Although recent research has extensively explored the definition, causes, influencing factors, and interventions for procrastination, our understanding of

its core psychological mechanisms remains insufficient. To address this gap, our research team has originally proposed the time decision model of procrastination (Zhang & Feng, 2020) and the triple neural structure network model (Chen, Liu, et al, 2020), which together provide a foundational theoretical framework for understanding the cognitive mechanisms and neural basis of procrastination. However, procrastination is a complex psychological and behavioral phenomenon involving at least three stages: evaluation, decision-making, and execution. Current research has investigated only single aspects of cognitive mechanisms or neural substrates, lacking an integrated cognitive neural model to systematically examine the mechanisms across all stages. Moreover, there is a dearth of causal or near-causal manipulative studies to validate the cognitive neural model, and no personalized precision treatment protocols for procrastination behavior disorder have been developed. Consequently, this project will first integrate the time decision model and triple neural structure network model to construct a comprehensive cognitive neural model of procrastination. Second, from causal and near-causal perspectives using cognitive interventions and neural regulation, we will systematically examine the cognitive neural mechanisms across the evaluation, decision, and execution stages to validate and refine the model. Finally, from a clinical application perspective, we will establish a screening-diagnosis system for procrastination behavior disorder and develop precision treatment protocols. This project will yield important theoretical contributions to uncovering the core cognitive neural mechanisms of procrastination while providing significant practical implications for its effective prevention and precise treatment.

2.1 Cognitive Mechanisms and Neural Basis of Procrastination

Why do people voluntarily delay tasks despite foreseeing negative consequences? How do they weigh the trade-offs between immediate action and procrastination? Researchers have approached these questions from various angles. Sirois (2013) proposed the short-term mood repair theory (SMRT) from an emotion regulation perspective, conceptualizing procrastination as a self-regulation failure where individuals prioritize repairing task-induced negative emotions over pursuing long-term outcomes. Steel (2006) introduced temporal motivation theory (TMT) from a time orientation perspective, with the formula: $M = \frac{E \times V}{\Gamma \times D}$, where E represents expectancy, V represents value, Γ represents individual sensitivity to delay, and D represents task deadline. When expectancy and task value increase, action motivation rises and procrastination decreases; when delay sensitivity or task deadline increases, action motivation decreases and procrastination increases. Ultimately, procrastination occurs because individuals are unwilling to start tasks now but hope to complete them in the future, requiring theories to fully explain this asymmetric choice between present and future.

The short-term mood repair theory explains why procrastinators are unwilling to execute tasks now by suggesting they delay to reduce task-induced negative

emotions, but fails to explain why they expect to complete tasks in the future. In contrast, TMT demonstrates that as task deadlines approach, action motivation increases and procrastination decreases, better explaining why procrastinators are willing to complete tasks later but inadequately addressing their current unwillingness. Given these limitations in explaining asymmetric decisions between present and future, our team proposed the time decision model of procrastination (TDM, see Figure 1 [Figure 1: see original paper]; Zhang, Liu & Feng, 2019; Zhang & Feng, 2020) to comprehensively explain why procrastinators are unwilling to start tasks now yet believe they will complete them later.

TDM posits that: first, the key to procrastination lies in the competition between action motivation and procrastination motivation; second, this competition simplifies to a trade-off between positive outcome utility and negative process utility; and third, both anticipated future negative processes and positive outcomes are subject to delay discounting, with discounting the negative process being the core purpose of procrastination. Current evidence supports TDM: when perceived negative process utility exceeds positive outcome utility, individuals procrastinate; negative process utility follows a hyperbolic discounting pattern over delay time, while positive outcome utility follows a hyperbolic increasing pattern as time progresses toward the deadline (Zhang & Feng, 2020).

Figure 1. The Time Decision Model of Procrastination

Decision formula for procrastination: E represents expectancy, V represents value, Γ represents delay sensitivity, D represents delay time. $D_{\{execution\}}$ represents the interval from now to the decided task execution time point, $D_{\{outcome\}}$ represents the interval from the decided execution time point to reward delivery (Zhang & Feng, 2020).

Procrastination is a complex psychological and behavioral phenomenon involving at least three stages: evaluation, decision-making, and execution (see Figure 2 [Figure 2: see original paper]; Zhang, Liu & Feng, 2019). Current research has focused primarily on the evaluation and decision stages, with less attention to execution. Deciding to act does not guarantee action; failing to persist in task completion also constitutes procrastination. Therefore, investigating the execution stage is equally crucial for reducing procrastination. According to TDM, the evaluation stage involves assessing the subjective value of negative processes and positive outcomes. The model identifies task aversion induced by negative processes as the primary source of procrastination motivation. The core purpose of procrastination is to discount task aversion—feeling less aversion when farther from task execution. Unlike task aversion, outcome utility from rewards or punishments can only be obtained or avoided after task completion, necessarily existing at some temporal distance from the present. As time progresses and the distance to outcome delivery decreases, experienced outcome utility increases (Zhang & Feng, 2020). Representing future processes or outcomes relies on episodic prospection: imagining negative processes exacerbates procrastination, while imagining positive outcomes reduces it (Wei & Feng, 2019); anticipated positive outcome value and anticipated negative process to-

gether optimally predict task execution intention (Yang et al, 2021a). These findings suggest episodic prospection may be a core psychological mechanism in the evaluation stage. Furthermore, TDM indicates procrastination motivation derives primarily from negative process utility, while action motivation depends on positive outcome utility. Individuals decide when to execute tasks by comparing these two utilities at different time points—when current positive outcome utility exceeds negative process utility, they act immediately; otherwise, they procrastinate. When motivations are balanced, self-control plays a regulatory role (Zhang & Feng, 2020). During decision-making, self-control promotes consideration of long-term rewards and generates foresighted action (Berkman et al, 2017), potentially reducing procrastination by increasing outcome value. However, even after deciding to act, procrastination remains possible. During execution, regulating aversive emotions is crucial for reducing procrastination. Research shows individuals with strong emotion regulation abilities can adjust strategies to focus on positive outcomes, thereby reducing aversion and persisting in tasks (Hennecke et al, 2019), highlighting the importance of emotion regulation during execution. Overall, comprehensively investigating all three stages and the key cognitive abilities involved represents a new direction for revealing procrastination’s cognitive mechanisms.

Neuroimaging evidence demonstrates that episodic prospection, self-control, and emotion regulation play critical roles in evaluation, decision, and execution stages, respectively. First, episodic prospection is central to task evaluation: weaker ability to imagine connections between tasks and outcome values correlates with increased procrastination, associated with reduced functional connectivity between the hippocampus and putamen. The hippocampus enables pre-experiencing delayed rewards, and decreased hippocampus-putamen connectivity reduces future reward perception, decreasing execution motivation and increasing procrastination (Zhang, Becker, et al, 2019). Further research reveals episodic prospection influences procrastination through both top-down cognitive control pathways (dorsolateral prefrontal cortex-inferior frontal gyrus, dorsolateral prefrontal cortex-precuneus) and bottom-up emotional processing pathways (hippocampus-insula) (Yang et al, 2021a). Second, self-control is crucial in procrastination decisions: structural studies show significant negative correlations between procrastination and dorsolateral prefrontal cortex (dlPFC) gray matter volume, providing empirical support for procrastination as a form of self-control failure (Liu & Feng, 2017). Resting-state studies reveal negative correlations between procrastination and functional connectivity of left dlPFC-lateral orbitofrontal cortex and left dlPFC-right dorsal middle frontal gyrus, which mediate the relationship between self-control and procrastination (Xu et al, 2021a). These findings suggest self-control deficits may be an important cognitive mechanism underlying procrastination. Finally, procrastination is closely associated with functional abnormalities in emotion regulation brain regions. Recent research focusing on emotion regulation strategies indicates right dlPFC gray matter volume mediates the relationship between expressive suppression strategy use and procrastination, offering new perspectives on emotion regula-

tion' s role in procrastination (Wang et al, 2022).

Building on previous research, Chen and Feng used voxel-based morphometry (VBM) to systematically investigate the neural structural basis of procrastination, proposing the triple neural structure network model: a self-control network centered on dlPFC and anterior cingulate cortex (ACC), an emotion regulation network centered on insula and orbital frontal cortex (OFC), and an episodic prospection network centered on ventromedial prefrontal cortex (vmPFC) and parahippocampal cortex (PHC) (see Figure 2 [Figure 2: see original paper]; Chen, Liu, et al, 2020). They proposed close relationships between self-control, emotion regulation, episodic prospection abilities and procrastination. Despite progress in understanding cognitive mechanisms and neural bases, an integrated theoretical model explaining the cognitive neural mechanisms of procrastination remains lacking—specifically, systematically examining how episodic prospection, self-control, and emotion regulation operate across different stages (evaluation, decision, execution).

Figure 2. The Triple Neural Structure Network Model of Procrastination

Note: Self-control network (blue): core regions include dorsolateral prefrontal cortex (dlPFC) and anterior cingulate cortex (ACC); Emotion regulation network (purple): core regions include orbital frontal cortex (OFC) and insula; Episodic prospection network (yellow): core regions include ventromedial prefrontal cortex (vmPFC) and parahippocampal cortex (PHC) (Chen, Liu, et al, 2020).

2.2 Psychological Intervention and Neural Regulation of Procrastination

Given procrastination's prevalence and harmfulness, researchers have conducted extensive intervention studies: (1) using emotion-focused strategies to reduce attention to task-related negative emotions (Eckert et al., 2016; Mirzaei et al., 2014); (2) changing irrational beliefs while establishing correct task cognition and enhancing intrinsic motivation (Hayes et al, 2013; Pychyl & Flett, 2012); (3) forming implementation intentions by developing action plans specifying when, where, and how to execute tasks (Lin, 2017); and (4) enhancing self-management and monitoring during task execution (Wäschle, 2014). However, previous interventions were not based on identified causal mechanisms, limiting their effectiveness and long-term efficacy. According to the TDM and triple neural structure network models, episodic prospection, self-control, and emotion regulation may be core cognitive abilities involved across procrastination stages (evaluation, decision, execution) (Chen, Liu, et al, 2020; Zhang & Feng, 2020a). Based on TMT and TDM, increasing evaluation of long-term outcome value may enhance task execution motivation and reduce procrastination (Steel, 2007; Zhang, Liu & Feng, 2019). Episodic prospection is crucial for constructing future outcome value during evaluation. The 2 (prospection direction: task process vs. task outcome) \times 2 (prospection content valence: positive vs. negative) model of

episodic prospection indicates that imagining positive outcomes (positively correlated with execution intention) and imagining negative processes (negatively correlated) together predict task execution intention (Yang et al, 2021a). This suggests procrastination may be reduced by manipulating prospection direction and content valence. Moreover, since procrastination largely stems from short-term mood repair needs (Sirois & Pychyl, 2013), emotion regulation ability during execution determines task success (Zhang, Liu & Feng, 2019). Recent research shows that using a “lesser of two evils” motivational conflict resolution strategy effectively regulates task aversion and reduces procrastination (Hou, 2021). Manipulating key factors like episodic prospection and emotion regulation can both test core cognitive neural mechanisms and provide theoretical foundations for developing effective long-term interventions.

In addition to cognitive interventions, neural regulation techniques such as transcranial magnetic stimulation (TMS) and transcranial direct current stimulation (tDCS) have attracted widespread attention due to their non-invasive nature, ease of operation, and unique clinical advantages. Combining TMS with MRI can better investigate brain networks and functional connectivity (Fox et al, 2012), while TMS or tDCS targeting dlPFC can treat depression (Kiebs et al, 2019). TDM suggests that trade-offs between positive outcomes and negative processes determine task initiation, with self-control playing a crucial regulatory role (Zhang & Feng, 2020). Our team has shown that high-definition tDCS targeting left dlPFC enhances execution intention by increasing task outcome value, thereby reducing procrastination (Xu et al, 2022), revealing for the first time the causal mechanism by which self-control modulates procrastination. Additionally, during task execution, regulating aversive emotions directly impacts success. The orbitofrontal cortex may play an important role in regulating anxiety and aversion (Rolls, 2004; Bechara, 2000), and although neural regulation of OFC has been used to maintain goal-directed behavior (Ouellet et al, 2015), no studies have examined its mechanisms in task execution. Overall, causal studies using non-invasive neural regulation to investigate self-control and emotion regulation mechanisms in procrastination are currently lacking.

3. Research Proposal

Based on the time decision model (Zhang & Feng, 2020) and triple neural structure network model (Chen, Liu, et al, 2020), this research will construct a cognitive neural model of procrastination and use cognitive interventions and non-invasive neural regulation (e.g., tDCS, TMS) to test and refine this model from a causal perspective, systematically elucidating the cognitive neural mechanisms and effective interventions for procrastination. Specific objectives include: (1) constructing the cognitive neural model based on TDM and the triple network model, investigating cognitive mechanisms and neural substrates from a recording and association perspective; (2) using cognitive interventions and neural regulation to validate and improve the model from a causal/near-causal perspective; and (3) from a clinical and applied perspective, establishing

a screening-diagnosis system and developing long-term interventions combining cognitive training (episodic prospection, emotion regulation) and neural regulation (tDCS, TMS), with precision medicine approaches for personalized treatment. The overall research framework is illustrated in Figure 3 [Figure 3: see original paper].

3.1 Study 1: Construction of the Cognitive Neural Model of Procrastination

This study will integrate TDM and the triple neural structure network model into a comprehensive cognitive neural model of procrastination. From a recording and association perspective, combining cognitive behavioral experiments, multimodal neuroimaging (task-based, resting-state, structural), and cognitive neurocomputational modeling, we will systematically examine the cognitive components and neural circuits in evaluation, decision, and execution stages.

First, we will investigate distinct neural encoding circuits for task process utility and task outcome utility during evaluation and their potential interaction mechanisms. Using a free-construction paradigm (Zhang et al, 2021), we will assess participants' evaluations of task process and outcome utilities during evaluation and their task execution intentions during decision (e.g., "Are you willing to execute this task within 24 hours?"), while recording neural activity with task-based fMRI. Cognitive neurocomputational modeling will establish associations between cognitive activity and neural activity, particularly in episodic prospection and value evaluation networks. Second, we will explore how self-control regulates the trade-off between process and outcome utilities during decision-making. Building on the previous step, we will measure neural activity during decision-making and use computational modeling to verify whether and how the self-control network (including core dlPFC regions) modulates the trade-off between process and outcome utilities—specifically, whether neural signals from the self-control network during decision-making can modulate evaluation-stage outcomes. Finally, we will investigate emotion regulation's role during execution and identify effective regulation strategies. We will measure emotion regulation abilities and strategies (Trait Emotional Intelligence Questionnaire; Petrides, 2009; Emotion Regulation Questionnaire; Gross & John, 2003) and neural network characteristics (including OFC, insula, and other emotion-related regions using resting-state fMRI), using these indicators to predict real-world task execution/completion and explain emotion regulation's role in the execution stage. Additionally, task-based fMRI will examine emotion regulation's mechanisms during execution.

3.2 Study 2: Testing the Cognitive Neural Model—Perspectives from Cognitive Intervention and Neural Regulation

This study will use cognitive interventions and neural regulation to validate and refine the cognitive neural model from causal/near-causal perspectives, investigating mechanisms across evaluation, decision, and execution stages. Our

team previously attempted to reduce procrastination through episodic prospection training and high-definition tDCS targeting dlPFC, finding that imagining positive outcomes or enhancing self-control region excitability reduced procrastination intentions, though the mechanisms remain unclear (Wei & Feng, 2019; Xu et al, 2022). Therefore, this study will employ rigorous experimental-control, pretest-posttest designs, manipulating core abilities (episodic prospection, self-control, emotion regulation) through cognitive training or neural regulation to examine changes in psychology, behavior, and brain function (functional connectivity, network efficiency of prospection, self-control, and emotion regulation networks) before and after intervention, testing the model from causal/near-causal perspectives.

First, the 2 (prospection direction: task process vs. task outcome) \times 2 (content valence: positive vs. negative) model indicates that imagining positive outcomes increases approach motivation while imagining negative processes increases avoidance motivation during procrastination (Yang et al, 2021). To investigate episodic prospection's role in evaluation, we will use experimental-control and pretest-posttest designs with a control group and two experimental groups (one training to increase positive outcome imagination, another to decrease negative process imagination), examining changes in procrastination intentions and actual behavior. Multiple mediation models will test whether effects occur through increased positive outcome utility or decreased negative process utility. Additionally, we will examine changes in functional connectivity and network properties (global topology such as small-worldness and network efficiency; local topology such as community structure and nodal centrality) of prospection and value evaluation networks, and whether these changes mediate training effects.

Second, we will investigate self-control's regulatory role in the trade-off between process and outcome utilities during decision-making. TDM suggests self-control may reduce procrastination by inhibiting negative emotions or enhancing outcome value evaluation (Zhang & Feng, 2020). Neuroimaging studies indicate dlPFC is the core region of self-control, with increased activation enhancing long-term goal value evaluation (Cohen & Lieberman, 2010; Han et al, 2018). Left dlPFC activation is closely related to negative emotion perception and regulation (Xie et al, 2019), and weakened dlPFC-OFC connectivity may increase attention to negative information and hinder emotion regulation, potentially increasing procrastination (Han et al, 2016). Additionally, self-control failure may involve disrupted dlPFC-vmPFC connectivity, affecting positive outcome evaluation and increasing procrastination tendencies (Wu et al, 2016). Therefore, dlPFC intervention may reduce procrastination through self-control, emotion regulation, and value evaluation networks. Specifically, we will establish control (sham stimulation) and experimental groups (repeated anodal tDCS over left dlPFC to enhance self-control), examining differences in negative process utility, positive outcome utility, execution intention, and actual procrastination rates before and after stimulation. Structural equation modeling will test interactive effects of process and outcome utilities on intention and behav-

ior, revealing self-control's cognitive mechanisms. Bayesian structural equation modeling will examine changes in global and local topological properties of the self-control network and their explanatory power.

Finally, we will investigate the emotion regulation network's role during execution and its specific mechanisms. During execution, effectively regulating task-related negative emotions is key to successful completion. OFC is a core region of the emotion regulation network, connecting to amygdala, striatum, insula, and cingulate cortex to encode and regulate emotional valence and arousal (Guillory & Bujarski, 2014; Rolls, 2004; Rolls & Grabenhorst, 2008). Enhanced left OFC-amygdala connectivity is associated with reduced negative emotion experience (Pourtois et al, 2006). Therefore, OFC activation through neural intervention may reduce procrastination by decreasing negative emotions during execution. We will establish control (sham) and experimental groups (repeated anodal tDCS over left OFC to enhance emotion regulation), using analytical approaches parallel to those for self-control to reveal emotion regulation's mechanisms.

3.3 Study 3: Clinical Intervention and Precision Treatment for Procrastination

First, to establish a screening-diagnosis system for procrastination behavior disorder, we will apply psychiatric symptom diagnostic systems and psychosocial functioning impairment criteria from a clinical and applied perspective to develop screening and diagnostic protocols that distinguish mild, moderate, and severe procrastination (i.e., pathological procrastination), guiding precision intervention development (Sheeran & Zimmerman, 2002; Zimmerman & Mattia, 2001). Second, to develop effective interventions with far-transfer effects, we will design specific cognitive interventions (focusing on episodic prospection and emotion regulation training) and neural regulation protocols (HD-tDCS or TMS targeting self-control and emotion regulation) for long-term treatment of diagnosed procrastination disorder patients. Finally, to enhance treatment efficacy through personalization, we will adopt precision medicine principles to assess cognitive-neural susceptibility profiles of procrastination patients, developing targeted individual cognitive and neural regulation protocols to improve outcomes and clinical translational value.

4. Theoretical Framework

Procrastination is a complex psychological and behavioral phenomenon involving at least three stages: evaluation, decision-making, and execution. To investigate its cognitive mechanisms, our team originally proposed the time decision model, explaining procrastination across these three stages (Zhang & Feng, 2020), and subsequently proposed the triple neural structure network model comprising episodic prospection, self-control, and emotion regulation networks (Chen, Liu, et al, 2020). Despite progress, an integrated theoretical model explaining the cognitive neural mechanisms remains lacking. Specifically, during

evaluation, value assessment of task processes and outcomes relies on episodic prospection. The episodic prospection network, centered on vmPFC and hippocampus, participates in self-related imagination and future outcome representation (Addis et al, 2009; Atance & O'Neill, 2001; Mirzaei et al, 2014; Motzkin et al, 2014). Imagining positive processes exacerbates procrastination, while imagining negative outcomes reduces it (Wei & Feng, 2019). During decision-making, when action and procrastination motivations are balanced, self-control plays a critical role (Zhang & Feng, 2020). The self-control network, centered on dlPFC and ACC, regulates cognitive resources and promotes pursuit of future outcomes (Botvinick, 2007; Marco-Pallarés et al, 2010), determining whether individuals act immediately or procrastinate. During execution, effectively regulating task-induced negative emotions is crucial for success. The emotion regulation network, centered on insula and OFC, encodes emotions and monitors/regulates negative affect (Kanai & Rees, 2011; Lindquist et al, 2012; Petrovic et al, 2016). Individuals with strong emotion regulation can effectively down-regulate negative emotions to reduce procrastination (Eckert et al, 2016b). Based on TDM and the triple network model, this project integrates them into a comprehensive cognitive neural model of procrastination (see Figure 4 [Figure 4: see original paper]) and systematically examines the cognitive neural mechanisms of episodic prospection, self-control, and emotion regulation across evaluation, decision, and execution stages.

Figure 4. The Cognitive Neural Model of Procrastination Behavior

From a research perspective, previous studies have primarily used recording and association approaches to link procrastination with these three abilities (Chen, Zhang, et al, 2020; Xu et al, 2021b; Yang et al, 2021a; Zhang, Liu & Feng, 2019; Zhang et al, 2021), but lack causal manipulative evidence for their specific roles across stages. This project will combine cognitive interventions (e.g., episodic prospection training; Yang et al, 2021a) and neural regulation (e.g., tDCS) to investigate mechanisms from a causal perspective, testing and refining the model.

From a clinical perspective, procrastination harms social functioning in work, learning, and health (Kim & Seo, 2015; Sirois, 2015; Steel & Ferrari, 2013) and negatively impacts societal and national development by reducing organizational efficiency and delaying policy implementation. Preventing and intervening in procrastination behavior disorder is therefore practically significant. While previous interventions focused on psychological and behavioral approaches, no clinical screening system exists for procrastination disorder patients, and no personalized, precise, and long-term psychological or neural regulation protocols have been developed. This project will establish a clinical screening-diagnosis system (Zimmerman & Mattia, 2001) and implement effective clinical interventions and precision treatments through cognitive and neural regulation approaches.

In summary, by constructing a cognitive neural model based on the dynamic psychological processes of procrastination (evaluation, decision, execution) and testing it through causal manipulations combining cognitive intervention and

neural regulation, this project will provide significant scientific value for elucidating core mechanisms and important practical significance for effective prevention and precision treatment of procrastination.

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