ACADEMIC PROCRASTINATION
THE UNDERLYING PSYCHOLOGICAL AND NEUROLOGICAL FACTORS

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Abstract

Summary

Academic procrastination is observed in 50-75% of students and is associated with several adverse effects on personal well-being and academic performance. Traditionally, academic procrastination is defined as voluntarily and irrationally delaying studying-related tasks. However, many discrepancies appeared in both psychological as well as in neurological research on procrastination. These inconsistencies resulted in a reinvestigation of the traditional outlook on procrastination, which led to the distinction between passive and active procrastination. Whereas passive procrastination is mainly associated with low self-control and high impulsivity, active academic procrastination is associated with extraversion and emotional stability. In other words, in active procrastination, the choice to delay tasks is made on purpose and not primarily to delay unpleasant tasks. The introduction of these two types of procrastination enhanced further research on this matter, which made it possible to further unravel the different neurological pathways involved in procrastination, as well as develop theoretical frameworks that can explain procrastination. The aim of this article is to elaborate on the underlying psychological and neurological factors in academic procrastination, describing both the several traits, cognitive aspects, and task characteristics that form the four theoretical frameworks that can explain academic procrastination, as well as elaborating on the subregions of the brain that are involved.

KEY WORDS: Task aversiveness, temporal decision theory, limbic system, prefrontal cortex, anterior cingulate cortex

Procrastination is often defined as the act of voluntarily delaying certain tasks and/or activities despite acknowledging that the delay will not result in more beneficial outcomes [1]. One form of procrastination is academic procrastination, which is a well-known phenomenon and refers to procrastination of learning- and studying-related actions [2]. In a study among undergraduates in China from 2018 (n = 1184), academic procrastination was reported in 74% of students [3]. A prevalence of 52% was found in another study from 2009 among Turkish students (n = 784) [4].

Academic procrastination can result in reduced personal well-being, and it can have negative effects within the academic domain [2]. An interview study among university students identified stress, illness, and exhaustion as health-related adverse effects of academic procrastination [5]. In addition, feelings of shame, anger, anxiety, a negative self-image, and social problems were frequently reported [5]. Another interview study among university counsellors produced similar findings [6]. Moreover, academic procrastination was found to be associated with lower grades, in particular coursework grades [7, 8].

Nevertheless, academic procrastination does not only have negative consequences [9, 10]. Chu *et al.* were the first to distinguish active from passive procrastination [9]. Passive procrastinators procrastinate to avoid tasks, which results in failure to complete the task in time, whereas active procrastinators decide to procrastinate intentionally, giving preference to working under time pressure [9]. Positive consequences of active procrastination include time efficiency, increased academic performance, and the perception of being in control of the situation [9, 10].

The causes and risk factors of academic procrastination have been studied extensively [1, 2, 11]. Several personality traits and task-level characteristics have been identified that contribute to procrastination from a more psychological view [1, 2, 11]. Consequently, various theoretical frameworks have been developed [1, 2, 11]. Building on these psychological theories, cognitive neuroscientists have studied the brain mechanisms underlying academic procrastination. From this perspective, the interplay between the limbic system and the prefrontal cortex are of particular interest. This article aims to elaborate on the factors underlying academic procrastination from both a psychological and neurological perspective.

Psychological perspective on procrastination

Many studies have reported psychological mechanisms underlying academic procrastination [1, 2, 11]. From this literature, the following general topics can be distinguished as psychological factors in academic procrastination: personality, cognitive ability, and task characteristics. Various theoretical frameworks on procrastination have been developed based on these psychological factors.

Personality

With regard to personality, two models have been used in research: the five-factor model of personality and the temperament and character model [12-15]. The five-factor model is most commonly used and distinguishes the following traits: agreeableness (e.g. kindness, generosity, helpfulness), conscientiousness (e.g. self-discipline, striving for achievement), extraversion (e.g. enthusiasm, sociability, high-energy), neuroticism (e.g. emotional instability), and openness (e.g. imaginativeness, curiosity) [12, 13].

Having low conscientiousness is a well-established predictor of academic procrastination [16-19]. Self-discipline, i.e. resistance to temptations or control over one's desires and emotions, is a facet of conscientiousness [12, 13]. Individuals with little self-discipline tend to prefer short-term satisfaction over long-term benefits, and,

thus, they are more vulnerable to procrastination [11]. Impulsivity, a facet of neuroticism, is the tendency to display behaviour with little or no forethought and is often aimed at satisfying short-term needs [11-13]. While some studies indicate that neuroticism predicts procrastination, others show weaker or no association [16-21]. Regarding the other three traits of the five-factor model, i.e. agreeableness, extraversion, and openness, results are even more inconsistent.

However, this inconsistency is partly solved by distinguishing between passive and active academic procrastination [9, 10]. Emotional stability (the opposite of neuroticism) and extraversion are predictors of active academic procrastination, in which the decision to procrastinate is made deliberately and with the intention to fulfil tasks in a time-efficient manner [10, 22, 23]. As an illustration, extroverts generally enjoy participating in many social activities and having busy schedules [22, 23]. A full schedule requires planning, which explains why extraverts are more likely to procrastinate actively [22, 23]. Altogether, passive and active procrastinators differ in personality, and, thus, they have different motives for procrastination.

Another way to study procrastination in light of personality is the temperament and character model [14, 15]. Temperament manifests in early development, while a character is developed later during life [14, 15]. Character is affected by one's temperament and socio-environmental factors [14, 15]. A dependable temperament profile is characterised by being highly affected by rewards, persistent but not afraid to take risks, and having low levels of novelty seeking [24, 25]. A well-developed character is defined by high levels of self-directedness (i.e. self-acceptance and personal goal development), cooperation, and self-transcendence (i.e. feeling part of the bigger picture) [24, 25]. The dependable temperament- and well-developed character profiles have previously been associated with health and happiness [24]. Both profiles are more often established in active than in passive procrastinators [25]. As an example, active procrastinators display lower levels of novelty seeking, meaning that their decisions rely less on impulses compared to passive procrastinators [25]. In short, studies suggest that active procrastinators are more likely to display temperament- and character profiles that are associated with health and happiness.

Cognitive ability

Besides personality traits, research also focuses on cognitive factors contributing to academic procrastination, one of which is the need for cognition. Need for cognition is the tendency to like and engage in activities that require mental effort [26]. This need for cognition is negatively correlated with passive procrastination, and even though a positive correlation with active procrastination is expected, this has not yet been established [23, 27, 28]. Another cognitive ability that is relevant to procrastination is emotional intelligence (EI). EI refers to accurately expressing, interpreting, and regulating emotions and using them in decision-making [29]. Similar to the need for cognition, EI is negatively correlated with passive academic procrastination [30, 31]. In addition, active procrastinators show higher levels of EI than passive procrastinators [25]. As mentioned above, EI includes actively taking decisions, e.g. the decision to procrastinate, based on the monitoring of feelings to regulate these feelings [29]. This implies that the accurate monitoring of feelings is used to avoid mental distress in active procrastination but used less in passive procrastination [25]. Both the need for cognition and EI, thus, seem to play a role in academic procrastination, but associations differ for active and passive procrastination.

Sanchez-Ruiz *et al.* noted that personality traits and EI both affect academic procrastination [32]. Therefore, they investigated the effect of the trait EI, which is compromised of several personality traits that impact how an individual responds in emotional situations [33]. The result suggested that trait EI negatively predicts passive academic procrastination [32]. Concretely, individuals who have difficulties in dealing with stressful situations because of specific traits, e.g. self-discipline and self-efficacy, are more likely to procrastinate on academic work passively [32]. This research emphasises that academic procrastination is affected by the combination of both personality and cognitive abilities.

Task characteristics and theoretical frameworks on procrastination

Task aversiveness and the emotion-regulation theory

Academic procrastination is dependent on the characteristics of the task and/or activity that is to be procrastinated [1, 2, 11]. Unpleasant or aversive tasks are more likely to be avoided [1, 2, 11]. As simple as it may sound, not liking the task is one of the most often mentioned reasons for procrastination [34, 35]. The emotion-regulation theory posits that procrastination can result from avoidance of negative feelings brought on by an aversive task [36, 37]. Procrastination can be a consequence of prioritising a short-term good mood (i.e. avoiding the unpleasant task) over long-term beneficial outcomes [36, 37]. According to the emotion-regulation theory and the five-factor model, impulsive individuals with little self-discipline are more likely to procrastinate aversive tasks passively [36].

Expected rewards/punishments and the 2x2 theory

Another task characteristic that affects procrastination is composed of the future incentives, i.e. the expected rewards or punishments [1, 2, 11]. Both task aversiveness and future incentives are taken into account by the 2x2 theory [38]. One aspect of the 2x2 theory is that the motivation to fulfil a task can be either approach- or avoidance-based [38]. An approach-based strategy implies that a task is completed because of its future rewards, while for an avoidance-based strategy, the main driver to accomplish a task is to avoid a punishment [38]. Goal-orientated subjects with an approach-based strategy (i.e. aiming to reach a certain level of competence) were less likely to use procrastination as a way to avoid aversive tasks [38]. Therefore, procrastination in goal-orientated subjects may be applied not to regulate an aversive task's negative emotions but to enhance performance via active procrastination [38]. The 2x2 model, thus, considers the effects of task aversiveness and future incentives and allows for a better distinction between active and passive procrastination compared to the previous theory.

Time to rewards/punishments and the temporal motivation theory

In addition, academic procrastination is highly dependent on the time to rewards or punishments [1, 2, 11]. Rewards and punishments have a greater influence on our decisions when the consequences are more immediate versus when they are in the future [1]. The temporal motivation theory focuses on how future incentives and time to incentives affect procrastination [Equation 1] [2, 11, 39].

$$Outcome\ utility = \frac{Expectancy\ x\ Value}{1 + Sensitivity\ to\ delay\ x\ Delay}$$

Equation 1

Expectancy refers to the perceived chance that a reward can be obtained or punishment can be avoided [39]. Value refers to how much this outcome is worth to the individual [39]. Motivation to

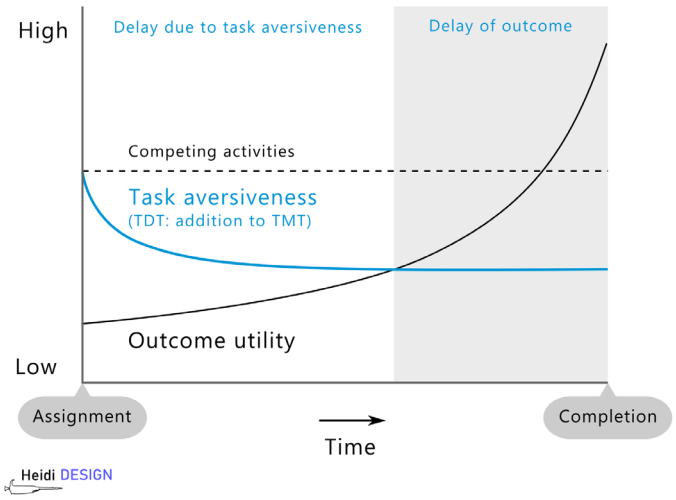

Figure 1: *Procrastination of a task explained by the temporal motivation theory (TMT) and temporal decision model (TDT – additional blue lines). This figure was created by combining Figure 1 of Steel et al. [1] and Figure 2 of Zhang et al. [11].*

fulfil a task (outcome utility) increases when an individual expects (expectancy) that a highly rewarded outcome (value) will be obtained [39]. An essential aspect of the temporal motivation theory is that everything depends on timing [39]. Motivation decreases when there is relatively much time until the reward or punishment will be obtained (delay) and when one is sensitive to this delay (sensitivity to delay) (Figure 1) [39]. The temporal motivation theory, thus, moves the focus from task aversiveness to (time to) future incentives.

Temporal decision theory

Zhang *et al.* noted that none of the above-mentioned theories suffices to fully explain academic procrastination [11]. The temporal motivation theory mainly focuses on (the timing of) future rewards and punishments, but not so much on task aversiveness [11, 39]. The emotion-regulation theory and the 2x2 theory, on the other hand, do not fully cover the importance of timing in procrastination [11, 36-38]. Therefore, the temporal decision theory was developed in which the decision to act or procrastinate depends on the task itself and (time to) future incentives [11]. At every moment in time, motivation to fulfil a certain (aversive) task at that time point is weighed against its future rewards or punishments [Equation 2] [11].

The outcome utility parameter from the temporal decision theory corresponds to the temporal motivation model [Equation 1], focussing on how motivation to act increases based on the *future* incentives and time to future incentives [11, 39]. The task aversiveness parameter refers to how much a task is perceived as unpleasant by the individual *at the time being* [11]. Only when outcome utility outweighs task aversiveness, the decision to act will be made, and the task will no longer be passively procrastinated (Figure 1) [11].

In conclusion, several models on procrastination have been developed, focussing on different aspects of tasks, i.e. task aversiveness, future incentives, and time to future incentives. The temporal decision theory is the only model that integrates the effects of all task-level characteristics on procrastination, potentially providing insight into how academic procrastination arises.

$$Decision = \underbrace{\frac{Expectancy\ (outcome)\ x\ Value\ (outcome)}{1+Sensitivity\ to\ delay\ (outcome)\ x\ Delay\ (outcome)}}_{Outcome\ utility} - \underbrace{\frac{Expectancy\ (aversiveness)\ x\ Value\ (aversiveness)}{1+Sensitivity\ to\ delay\ (aversiveness)\ x\ Delay\ (aversiveness)}}_{Task\ aversiveness}$$

Equation 2

Neurological perspective on procrastination

Having discussed how the psychological factors are involved in academic procrastination, the next section of this article will address the underlying neurological aspects of academic procrastination, of which two brain regions are of particular interest: the limbic system and the prefrontal cortex (PFC) (Figure 2). Relevant structures of both these regions will be discussed first, after which the results of several studies regarding procrastination will be given.

The limbic system

The limbic system plays a vital role in emotions, memory, motivation, and pleasure [40]. The region contains several structures, among which the amygdala is especially relevant in procrastination [40, 41]. The amygdala is best known for its role as a threat or fear generator [40, 42]. It receives input from all senses and associates those senses with emotions [40, 42]. In simple terms: the amygdala warns you about the possible adverse effects of a particular action and is shown to be larger in procrastinators [40, 41].

The parahippocampal gyrus/cortex (PHC), another limbic structure known to play a role in episodic memory and future thinking, is also relevant in the context of procrastination [40, 43, 44]. Several studies observed that interindividual differences in procrastination are linked to altered spontaneous metabolism or activity in the PHC and the prefrontal cortex [11]. The effects of certain personality traits on procrastination, such as future time perspective, might be mediated by certain parahippocampal pathways [45]. Furthermore, the PHC may mediate task aversiveness, which plays a vital role in emotion regulation theory, the 2x2 model, and the temporal decision theory [11, 36-38]. Although the temporal decision theory states that the PHC modulates both task aversiveness as outcome utility, it is too early to specify the exact association between PHC and procrastination [11].

An additional relevant limbic structure is the anterior cingulate cortex (ACC) that connects to both the 'emotional' limbic system and the 'cognitive' PFC [40, 43, 46]. The ACC is a system that executes goal-oriented actions to attain rewards and avoid negative outcomes and is involved in making adjustments for temporal delays by evaluating potential costs and benefits [43]. It has a cognitive component located dorsally and an emotional component located ventrally [46].

The prefrontal cortex

The PFC is a part of the frontal lobe and manages executive functions, which are a set of neurological processes involved in cognitive control and self-regulation [47]. Executive functions are crucial for individuals to plan and finish tasks, and they generally refer to processes involved in controlling short-sighted and goal-oriented behaviour [47, 48].

Considering that the PFC has these fundamental effects, this region can either positively or negatively affect competencies such as self-control, planning, decision-making, and problem-solving [47, 48].

These cognitive functions are complex; thus, it is unlikely that merely one brain region is responsible for them [47]. Nevertheless, evidence has shown that the PFC is of considerable importance in performing executive functions [47].

Each of the subregions of the PFC is suspected to be associated with slightly different aspects of cognition [47]. There is no clear consensus on these PFC subregions; however, standard demarcations include the dorsolateral, the dorsomedial, the ventrolateral, the ventromedial, and the orbitofrontal PFC [47]. The dorsolateral PFC is suggested to manage cognitive processes like planning and working memory [47, 49]. It is mainly involved in problem-solving and directing and maintaining attention to a task [47, 49]. Therefore, the dorsolateral PFC could play a role in several of the psychological theories mentioned before.

Whereas the dorsolateral PFC mainly contributes to executive functioning and cognitive control, the ventromedial PFC is assumed to be mainly involved in integrating signals from many brain regions [47, 49]. It receives information from several brain structures, including the amygdala, and is sensitive to the reward associated with a certain stimulus [50]. Furthermore, the ventrolateral PFC seems to be involved in response inhibition, which is a crucial executive function referring to the suppression of actions that are considered inappropriate in a given circumstance and interfere with goal-driven behaviour [51]. Lastly, the orbitofrontal PFC is closely related to limbic structures, including the amygdala and ACC, and is, thus, assumed to be relevant concerning the ability to make decisions based on emotional information [43, 47, 52]. The orbitofrontal PFC delivers inputs to the ACC with regard to the value of outcomes of certain goals [43, 52].

Neural mechanisms underlying procrastination

As stated before, procrastination results from an interaction between the limbic system, including the amygdala and the prefrontal cortex. Schlüter *et al.* examined the neural basis of interindividual differences in action control and procrastination [41]. The brains of 264 healthy individuals (mainly university students between 18 and 35 years old) were examined using MRI, which revealed that procrastination positively correlates with the grey matter volume of the amygdala [41]. According to the authors, the amygdala is responsible for fear-motivation behaviour [41]. In situations where a decision has to be made, the amygdala helps determine whether certain stimuli or conditions can be considered a threat [41]. In this respect, the authors suggested that individuals with a larger amygdala might more strongly weigh previous negative experiences, resulting in more concern for a possible negative outcome [41]. These negative experiences might have more power over decision-making, leading to procrastination to avoid undesirable consequences [41]. Alongside a larger amygdala volume, the study also linked procrastination to weaker connectivity between the amygdala and the dorsal ACC, which is essential in self-control [41]. However, it is unknown whether people who procrastinate have larger amygdala volume to start with or whether this has developed over time due to other factors. This lack of known causality has to be taken into account when interpreting these results.

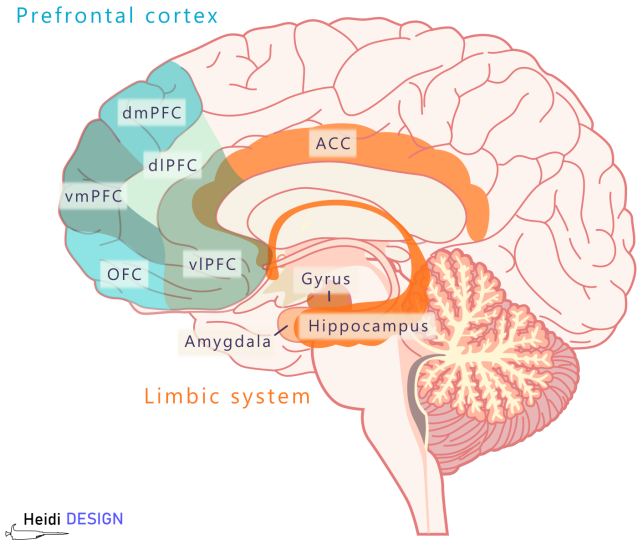

Figure 2: *Overview of brain regions relevant in terms of procrastination. The limbic system includes the amygdala, parahippocampal cortex (PHC), and anterior cingulate cortex (ACC). The prefrontal cortex (PFC) is divided into the dorsomedial PFC, the dorsolateral PFC, the ventromedial PFC, the ventrolateral PFC, and the orbitofrontal PFC.*

In addition to the amygdala, other brain structures are implicated in procrastination as well. Zhang *et al.* showed that procrastination has a positive correlation with the activity of the ventromedial PFC and PHC; a negative link was observed with the activity of the anterior PFC [53]. These results suggest that procrastination might be related to an overactive default mode network, which is a set of brain areas that show activity when individuals are not focused on the external environment (i.e. when resting, dreaming, or being unfocused) [53]. The researchers suggest that in individuals with a high procrastination tendency this network might interferes with the prefrontal cortex that is responsible for executive function, which leads to the higher tendency to procrastinate a task [53].

In a more recent study, Chen *et al.* used a sample of 688 subjects to explore the brain morphological characteristics of procrastination in both brain size and shape [54]. Several advanced brain imaging techniques were used to link procrastination to the grey matter volume and grey matter density of the brain [54]. A positive correlation was found between procrastination and the grey matter volume of the ACC and the insular cortex and PHC [54]. It turned out that the grey matter volume of the dorsolateral PFC was negatively linked to procrastination [54]. Procrastination was also positively associated with grey matter density of the ACC, ventromedial PFC, and CT complexity of orbitofrontal PFC [54]. In other words, it was found that the brain morphological features mentioned above can be considered as strong predictors for procrastination [54]. The authors described three brain subsystems to clarify the neural components related to procrastination. These are the self-control network (including the dorsolateral PFC and ACC), the emotional regulation network (including the orbitofrontal PFC and insular), and the episodic network (including the ventromedial PFC and PHC) [54].

Whether and how these brain networks interact and influence procrastination was elucidated in a more recent study performed by the same researchers [55]. In addition, this study aimed to capture neural biomarkers of procrastination using white matter microstructures and network features [55]. A positive association was found between limbic white matter tracts and procrastination [55]. Furthermore, the study revealed that the interconnection of the white matter of the frontoparietal and limbic systems is linked to procrastination. This outcome shows the role of interaction between the self-control system (ruled by the frontoparietal system) and the emotional process system (ruled by the limbic system) in procrastination [55]. In sum, several limbic and prefrontal regions are

involved in the concept of academic procrastination, which can be viewed as a result of interaction between these structures.

Conclusion

Procrastination can be viewed from a psychological and neurological point of view. Psychologically speaking, inconsistent results in previous research can be partly solved by dividing academic procrastination into two types: passive and active procrastination. Four models to frame the role of personality in procrastinators have been described, and the most important personality traits involved in general academic procrastination are impulsivity and little self-control, whereas extraversion and emotional stability seem to be predictors of active academic procrastination only. Cognitive factors, such as the need for cognition and EI, were negatively correlated with passive procrastination. Research also demonstrated that task characteristics influence procrastination. Tasks aversiveness seems to have a higher occurrence in tasks that are experienced as unpleasant. Finally, procrastination seems also to be dependent on the expected reward or punishment and the time at which these can be expected, as explained by the temporal motivation and temporal decision theory.

At a neurological level, procrastination has been positively linked to a larger volume of the amygdala and a weaker connection to the ACC. Research has also found that procrastination might depend on the activity of the ventromedial PFC and PHC. Thus, various subregions of the limbic system and the prefrontal cortex are relevant for the neurological understanding of academic procrastination. In this vein, procrastination might be a result of constant interaction between these two systems. The limbic system overrides the prefrontal cortex, causing procrastination; a universal affliction that is still of high interest in the neurological and psychological field.

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References

1. Steel, P. The nature of procrastination: a meta-analytic and theoretical review of quintessential self-regulatory failure. *Psychological bulletin* **133**, 65-94 (2007).
2. Steel, P. & Klingsieck, K. Academic Procrastination: Psychological Antecedents Revisited. *Australian Psychologist* **51**, 36-46 (2016).
3. Zhang, Y.*, et al.* Self-efficacy for self-regulation and fear of failure as mediators between self-esteem and academic procrastination among undergraduates in health professions. *Advances in health sciences education : theory and practice* **23**, 817-830 (2018).
4. Ozer, B.U.*, et al.* Exploring academic procrastination among Turkish students: possible gender differences in prevalence and reasons. *The Journal of social psychology* **149**, 241-257 (2009).
5. Grunschel, C.*, et al.* Exploring reasons and consequences of academic procrastination: An interview study. *European Journal of Psychology of Education* **28**(2012).
6. Patrzek, J.*, et al.* Academic Procrastination: The Perspective of University Counsellors. *International Journal for the Advancement of Counselling* **34**(2012).
7. Klassen, R.*, et al.* Academic procrastination of undergraduates: Low self-efficacy to self-regulate predicts higher levels of procrastination. *Contemporary Educational Psychology* **33**, 915-931 (2008).
8. Morris, P. & Fritz, C. Conscientiousness and procrastination predict academic coursework marks rather than examination performance. *Learning and Individual Differences* **39**(2015).
9. Chu, A.H. & Choi, J.N. Rethinking procrastination: positive effects of "active" procrastination behavior on attitudes and performance. *The Journal of social psychology* **145**, 245-264 (2005).
10. Choi, J.N. & Moran, S.V. Why not procrastinate? Development and validation of a new active procrastination scale. *The Journal of social psychology* **149**, 195-211 (2009).
11. Zhang, S.*, et al.* To do it now or later: The cognitive mechanisms and neural substrates underlying procrastination. *Wiley interdisciplinary reviews. Cognitive science* **10**, e1492 (2019).
12. Mccrae, R.R. & Costa, P.T., Jr. Validation of the five-factor model of personality across instruments and observers. *Journal of personality and social psychology* **52**, 81-90 (1987).
13. Poropat, A.E. A meta-analysis of the five-factor model of personality and academic performance. *Psychological bulletin* **135**, 322-338 (2009).
14. Cloninger, C.R.*, et al.* A psychobiological model of temperament and character. *Archives of general psychiatry* **50**, 975-990 (1993).
15. Cloninger, C.R. *Feeling good: The science of well-being*, (Oxford University Press, New York, NY, US, 2004).
16. Johnson, J.L. & Bloom, A.M. An analysis of the contribution of the five factors of personality to variance in academic procrastination. *Personality and Individual Differences* **18**, 127-133 (1995).
17. Schouwenburg, H.C. & Lay, C.H. Trait procrastination and the Big-five factors of personality. *Personality and Individual Differences* **18**, 481-490 (1995).
18. Van Eerde, W. A meta-analytically derived nomological network of procrastination. *Personality and Individual Differences* **35**, 1401-1418 (2003).
19. Watson, D.C. Procrastination and the five-factor model: a facet level analysis. *Personality and Individual Differences* **30**, 149-158 (2001).
20. Lay, C.H. Trait procrastination, agitation, dejection, and self-discrepancy. in *Procrastination and task avoidance: Theory, research, and treatment.*, Vol. 97-112 (Plenum Press, New York, NY, US, 1995).
21. Lay, C.H. Trait procrastination and affective experiences: Describing past study behavior and its relation to agitation and dejection. *Motivation and Emotion* **18**, 269-284 (1994).
22. Kim, S.*, et al.* Procrastination, personality traits, and academic performance: When active and passive procrastination tell a different story. *Personality and Individual Differences* **108**, 154-157 (2017).
23. Zhou, M. The role of personality traits and need for cognition in active procrastination. *Acta Psychologica* **199**, 102883 (2019).
24. Cloninger, C.R. & Zohar, A.H. Personality and the perception of health and happiness. *Journal of affective disorders* **128**, 24-32 (2011).
25. Zohar, A.H.*, et al.* Active and passive procrastination in terms of temperament and character. *PeerJ* **7**, e6988-e6988 (2019).
26. Cacioppo, J.*, et al.* Dispositional Differences in Cognitive Motivation: The Life and Times of Individuals Varying in Need for Cognition. *Psychological bulletin* **119**, 197-253 (1996).
27. Sarmány Schuller, I. Procrastination, need for cognition and sensation seeking. *Studia Psychologica* **41**, 73-85 (1999).
28. Laethem, S.*, et al.* Personality Correlates of the Melbourne Conflict Decision-Making Styles: Contribution of Need for Cognition and Need for Closure. *SSRN Electronic Journal* (2003).
29. Salovey, P. & Mayer, J.D. Emotional Intelligence. *Imagination, Cognition and Personality* **9**, 185-211 (1990).
30. Deniz, M.*, et al.* An Investigation of Academic Procrastination, Locus of Control, and Emotional Intelligence. *Educational Sciences: Theory and Practice* **9**(2009).

31. Wan, H.C., *et al.* Understanding non-work presenteeism: Relationships between emotional intelligence, boredom, procrastination and job stress. *Personality and Individual Differences* **65**, 86-90 (2014).
32. Sanchez-Ruiz, M.J. & El Khoury, J. A Model of Academic, Personality, and Emotion-Related Predictors of University Academic Performance. *Frontiers in psychology* **10**, 2435 (2019).
33. Petrides, K., *et al.* The Location of Trait Emotional Intelligence in Personality Factor Space. *British journal of psychology (London, England : 1953)* **98**, 273-289 (2007).
34. Anderson, E.M. The relationships among task characteristics, self-regulation and procrastination. *ProQuest Information & Learning* (2001).
35. Kachgal, M., *et al.* Academic Procrastination Prevention/ Intervention: Strategies and Recommendations. *Journal of Developmental Education* **25**, 14-24 (2001).
36. Sirois, F. & Pychyl, T. Procrastination and the Priority of Short-Term Mood Regulation: Consequences for Future Self. *Social and Personality Psychology Compass* **7**, 115–127 (2013).
37. Sirois, F.M. Absorbed in the moment? An investigation of procrastination, absorption and cognitive failures. *Personality and Individual Differences* **71**, 30-34 (2014).
38. Strunk, K.K., *et al.* Development and validation of a 2×2 model of time-related academic behavior: Procrastination and timely engagement. *Learning and Individual Differences* **25**, 35-44 (2013).
39. Steel, P. & König, C. Integrating Theories of Motivation. *Academy of Management Review* **31**, 889-913 (2006).
40. Rajmohan, V. & Mohandas, E. The limbic system. *Indian journal of psychiatry* **49**, 132-139 (2007).
41. Schlüter, C., *et al.* The Structural and Functional Signature of Action Control. *Psychological science* **29**, 1620-1630 (2018).
42. Balleine, B.W. & Killcross, S. Parallel incentive processing: an integrated view of amygdala function. *Trends in neurosciences* **29**, 272-279 (2006).
43. Rolls, E.T. The cingulate cortex and limbic systems for emotion, action, and memory. *Brain structure & function* **224**, 3001-3018 (2019).
44. Aminoff, E.M., *et al.* The role of the parahippocampal cortex in cognition. *Trends in cognitive sciences* **17**, 379-390 (2013).
45. Liu, P. & Feng, T. The effect of future time perspective on procrastination: the role of parahippocampal gyrus and ventromedial prefrontal cortex. *Brain imaging and behavior* **13**, 615-622 (2019).
46. Heilbronner, S.R. & Hayden, B.Y. Dorsal Anterior Cingulate Cortex: A Bottom-Up View. *Annual review of neuroscience* **39**, 149-170 (2016).
47. Funahashi, S. & Andreau, J.M. Prefrontal cortex and neural mechanisms of executive function. *Journal of physiology, Paris* **107**, 471-482 (2013).
48. Carlén, M. What constitutes the prefrontal cortex? *Science (New York, N.Y.)* **358**, 478-482 (2017).
49. Nejati, V., *et al.* The role of dorsolateral and ventromedial prefrontal cortex in the processing of emotional dimensions. *Scientific reports* **11**, 1971 (2021).
50. Kim, H., *et al.* Overlapping responses for the expectation of juice and money rewards in human ventromedial prefrontal cortex. *Cerebral cortex (New York, N.Y. : 1991)* **21**, 769-776 (2011).
51. Chikazoe, J. Localizing performance of go/no-go tasks to prefrontal cortical subregions. *Current opinion in psychiatry* **23**, 267-272 (2010).
52. Rolls, E.T., *et al.* The orbitofrontal cortex: reward, emotion and depression. *Brain communications* **2**, fcaa196 (2020).
53. Zhang, W., *et al.* Identifying the Neural Substrates of Procrastination: a Resting-State fMRI Study. *Scientific reports* **6**, 33203 (2016).
54. Chen, Z., *et al.* Brain Morphological Dynamics of Procrastination: The Crucial Role of the Self-Control, Emotional, and Episodic Prospection Network. *Cerebral cortex (New York, N.Y. : 1991)* **30**, 2834-2853 (2020).
55. Chen, Z., *et al.* Neural markers of procrastination in white matter microstructures and networks. *Psychophysiology* **58**, e13782 (2021).