Instant Enjoyment above Sleep: A Cross-sectional Study on the Relationship between Delay Discounting and Sleep Health with the Mediating Role of Bedtime Procrastination

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Abstract

Background: Sleep health is crucial for individual's well-being, encompassing subjective satisfaction, timing, duration, efficiency, and sustained alertness. Bedtime procrastination, defined as delaying bedtime without external reasons, is a common behavior that disrupts sleep health and reflects self-regulation failures.

Method: Thiscross-sectional mediation study involved 106 university students (76 females, mean age 23.90 years) to examine the relationship between delay discounting (evaluated via the Monetary Choice Questionnaire) and sleep health (assessed using the SATED questionnaire), mediated by bedtime procrastination (measured with the Bedtime Procrastination Scale).

Results: Delay discounting negatively predicted sleep health ($\beta = -5.55$, $p = 0.017$), but bedtime procrastination did not significantly mediate this relationship (indirect effect $\beta = -0.21$, $p = 0.99$). Bedtime procrastination independently negatively affected sleep health ($\beta = -1.12$, $p < 0.001$).

Conclusions: While delay discounting directly impacts sleep health, bedtime procrastination did not mediate this relationship as hypothesized. These findings underscore the complexity of behavioral influences on sleep and suggest the need for tailored interventions targeting delay discounting to improve sleep health.

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Sleep is a fundamental aspect of individuals' overall well-being. Described as a physically restorative process, sleep plays not only a key role in physical growth and energy metabolism, but also mediates psychosocial factors' influence on health (Robles & Carroll, 2011). Therefore, taking good care of one's sleep health is of significant importance.

Defined by Buysse (2014), "sleep health is a multidimensional pattern of sleep-wake-fulness, adapted to individual, social, and environmental demands, that promotes physical and mental well-being" (p. 12). It provides a comprehension of what good sleep encompasses: (a)subjective satisfaction (the subjective assessment of "good" sleep); appropriate timing (the appropriate placement of sleep within the 24-hour day); adequate duration (sufficient total amount of sleep obtained per 24 hours); high efficiency (the ease of falling asleep and returning to sleep), and sustained alertness during waking hours. Good sleep health is protective for individuals' well-being overall. Without it, the risk of physical and mental health problems may rise, such as mortality, obesity, diabetes, hypertension (Buxton & Marcelli, 2010), and depression (Baglioni et al., 2001). Moreover, sleep health is good for cognitive function (e.g. impaired neurobehavioral performance; Van Dongen et al., 2004).

There are various detrimental behaviors to sleep health. A commonly experienced one is bedtime procrastination, defined as going to bed later than intended with no external circumstances accountable for doing so (Kroese et al., 2014). It describes when people miss the appropriate timing to sleep, conceptually violating the appropriate timing of sleep health. bedtime procrastination as a form of procrastination in general can also be seen as a failure in self-regulation. Self-regulation refers to the ability to manage one's response in pursuit of long-term goals (Pilcher et al., 2015). People with lower trait self-regulation experience more inner conflicts between distractions and their goal (Schneider et al., 2019) and are also

more likely to engage in procrastination (Steel, 2007). When Despite the willingness of regulating one's sleep, people can be led astray by various temptations and distractions (watching TV, browsing social media, etc.), and end up delaying their bedtime (Nauts et al., 2019).

As reviewed in a study by Hill et al (2022), bedtime procrastination interferes with various sleep outcomes, including shorter sleep duration, lower sleep quality, and higher daytime fatigue, potentially exerting negative impact on various dimensions of sleep health. Therefore, our first aim in this study is to demonstrate the association between bedtime procrastination and sleep health. While distinct dimensions such as sleep duration, quality, and daytime fatigue have been assessed, this study for the first time examines the impact of bedtime procrastination on sleep health from a comprehensive perspective, which helps to look at the overall effect.

Another feature of bedtime procrastination is foreseeably being worse off (Kroese et al., 2016). Bedtime procrastination can be the result of deliberately weighing the pros and cons or be reflected in an after-the-fact realization (Kroese et al., 2016). In the former case, people would rather engage in other activities than go to bed on schedule despite knowing the bad consequences. In the latter case, participants would admit the negative consequences when asked to reflect on their behavior. Either way, procrastinators display a clear preference for instant enjoyment by trading their sleep time over daytime well-being the next day and even sleep health in the long run. This behavior tendency is understandable, in a way that the benefit of keeping a good sleep habit feels less appealing and therefore outweighed by the instant pleasure one can get from other pre-sleep activities.

This phenomenon can be depicted by delay discounting, "the decrease in the present value of a future outcome as the delay to that outcome increases"(Kirby, 2009, p. 457), The speed of which is represented by the coefficient k (Mazur, 1987). People who value the future outcomes of their actions less tend to make more impulsive choices (Rachlin, 2000). This is reflected in the relationship between delay discounting and various health behaviors. Delay discounting as a trans-disease process in multiple physical health conditions and behavioral health disorders (Bickel et al., 2019) is

associated with a wide range of disadvantageous health behaviors, such as drug abuse (MacKillop et al., 2011), obesity (Barlow et al., 2016), risky sexual behaviors (Johnson et al., 2015), and other maladaptive behaviors (e.g., gambling; Alessi & Petry, 2003), which all share the common: potentially rewarding in the short term but detrimental for one's health in the long term. This short-sighted tendency is thought to be reinforced when internal resources (e.g., restoration of glucose) that allow for self-control are low after repeated self-control actions, resembling an exhausted muscle after intense physical exertion (Muraven & Baumeister, 2000; Pilcher et al., 2015). Especially before bedtime, after a day of making decisions, people's self-control resources are depleted. As a result, it becomes more difficult for them to make rational choices.

Sleep as a restorative process for organism (Robles & Carroll, 2011) "may help restore necessary internal resources for self-control" (Pilcher et al., 2015), and also resources for self-regulation (Barnes, 2012). With higher self-control strength, people are more capable of resisting instant temptations in the purchase of long-term goals. This is consistent with the finding that habitual shortage of sleep is likely to cause increased delay discounting (Curtis et al., 2018). However, short-term sleep deprivation's effect on delay discounting is inconsistent and debatable (Downey et al., 2022). This could be due to the stable trait nature of delay discounting (Kirby, 2009), which suggests it's more likely for delay discounting tendency to influence sleep habits than the other way around. To be specific, individuals with a higher tendency for delay discounting are more likely to undervalue the benefits of going to bed on time, especially when their self-control resources are low. This can lead to impulsive choices of engaging in pre-sleep activities, resulting in bedtime procrastination and, over time, damaging their sleep health.

While the existence of a bidirectional relationship between delay discounting and sleep outcomes remains unclear (Massar & Chee, 2019), gaining a better understanding of this relationship will help us to develop more targeted interventions for sleep problems. Specifically, more exploration into the effect of delay discounting on sleep is needed. Moreover, previous studies mainly focused on the association of

delay discounting with a single or a few aspects of sleep, such as sleep quality (Law & Rasmussen, 2024), sleep duration, bedtime, and wake time (Libedinsky et al., 2013). Yet sleep health as a multi-dimensional concept may give us a more comprehensive understanding of sleep behavior. So, in this research, sleep health was used as an indicator to draw a bigger picture of impulsive decision-making in the sleep domain. The second aim of this study is to investigate how delay discounting influences sleep health through the potential pathway of bedtime procrastination. The hypotheses of the study are:

H1: The study hypothesizes a negative association between delay discounting and sleep health.

H2: Building upon the first hypothesis, the study proposes that bedtime procrastination serves as a mediating mechanism through which delay discounting influences sleep health.

Figure 1 shows the model for the assumption model that describes the relationship among variables of interest.

Figure 1

Assumption Model for the Mediation Effect of bedtime procrastination
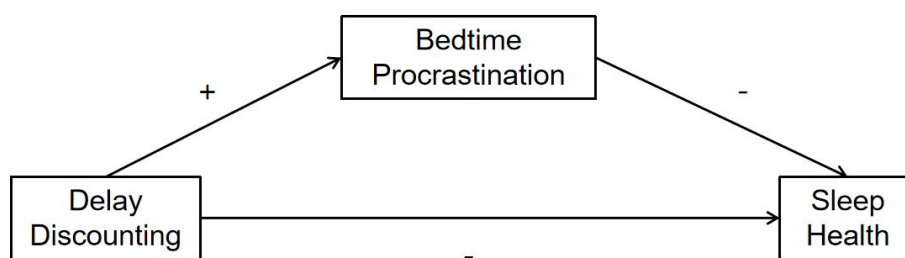
This study is pioneering in examining the underlying mechanisms driving procrastination behavior in the context of sleep, thereby expanding existing knowledge and enriching theories related to self-control, decision-making, and behavioral interventions. It also suggests that addressing delay discounting tendencies, for instance through techniques like episodic future thinking (EFT) and transcranial

magnetic stimulation (TMS), could be an effective strategy for tackling sleep problems. Additionally, it contributes to the solidification of implementing situational strategies to reduce the allure of distractions to promote healthier sleep behaviors.

Method

Design

This mediation cross-sectional study aims to investigate the effect of delay discounting tendency on sleep health and the potential pathway of bedtime procrastination. This research was approved by the Ethics Committee of the Faculty of Social and Behavioural Sciences of Utrecht University filed under number 24-0676.

Participants

The survey was conducted on Qualtrics, with recruitment efforts involving both online and offline strategies. Offline recruitment included direct engagement with potential participants and the distribution of promotional posters. Online recruitment was facilitated through social media platforms such as WeChat, Facebook, and WhatsApp, as well as the SONA system, utilizing both convenience sampling and snowball sampling methods.

To determine the necessary sample size, an a priori power analysis was performed using G*Power version 3.1.9.7 (Faul et al., 2007). This analysis was based on data from Kroese et al. (2016), which explored the mediating effect of bedtime procrastination between self-control and insufficient sleep. The effect size reported in the study was 0.132, classified as small according to Cohen's (1988) criteria. With a significance level of $\alpha = .05$ and a desired power of .80, the minimum required sample size was calculated to be N = 77.

Ultimately, a total of 105 university students voluntarily participated in the study without receiving any compensation. The sample consisted of individuals from 16 different nationalities (see Table 1), most of them are from China (N = 48) and the Netherlands (N = 43). 76 of the sample are females, 27 are males, 1 non-binary individual, and one participant preferred not to disclose their gender. The average age

of participants was 23.90 years (SD = 4.07), ranging from 18 to 45 years (see Figure 2). Among them, the majority were undergraduate students (N = 48), followed by Master's students (N = 43). The sample also included 8 PhD students, 2 Pre-Master's students, 1 post-doctoral researcher, and 2 individuals who selected "others" for their educational status (see Figure 3).
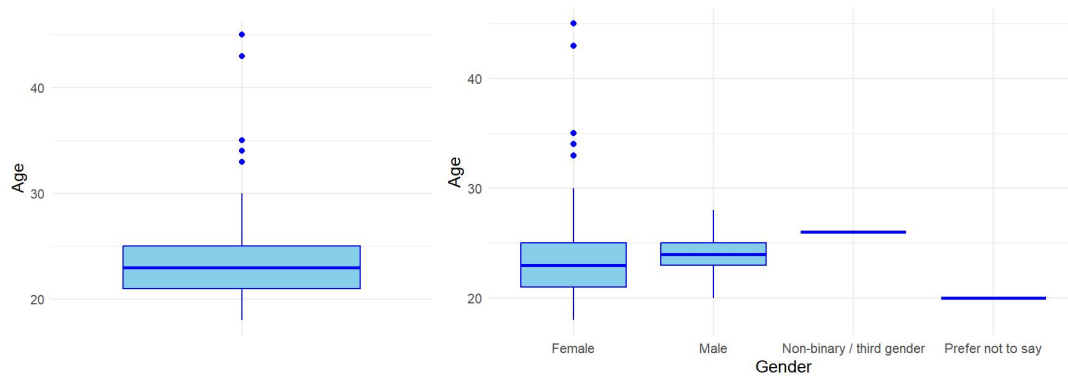
Table 1

Nationality of participants

Nationality	Count
China	48
Taiwan	1
Netherlands	41
Germany	3
Albania	1
Austria	1
UK	1
Netherlands/Turkey	1
Philippines	1
Greece	1
Hungary	1
Italy	1
Lithuania	1
Luxembourg	1
Morocco	1
South Africa	1

Figure 2

Box Chart of Age of Participants

Measures

    Sleep health. Sleep health was measured by the Satisfaction, Alertness, Timing, Efficiency and Duration Questionnaire (SATED; Buysse, 2014). This questionnaire is composed of 5 items (e.g. "Are you satisfied with your sleep?") rated on a scale ranging from 0 (*Rarely/Never*) to 2 (*Usually/Always*). The total for all items ranges from 0 (*poor sleep health*) to 10 (*good sleep health*). This questionnaire has been tested to be reliable and valid in previous study (Cronbach's α = 0.77; Benítez et al., 2020).

    Bedtime procrastination. bedtime procrastination was measured by the Bedtime Procrastination Scale (Kroese et al., 2014). This 9-item scale (e.g. "I go to bed later than I had intended.") was answered on 5-point scales ranging from 1 (*never*) to 5 (*always*). In this research, the Bedtime Procrastination Scale showed an acceptable internal consistency with a Cronbach's α of 0.86.

    Delay discounting. Delay discounting was evaluated by the Monetary Choice Questionnaire (MCQ; Kirby et al., 1999). It contains 27 dichotomous choice items pitting a smaller immediate reward (SIR) against a larger delayed reward (LDR). For example, participants were asked, "Would you prefer (a) $34 today or (b) $35 in 186 days?" The magnitudes of delayed rewards were grouped into three categories: small ($25–$35), medium ($50–$60), and large ($75–$85). In this research, an excel-based spreadsheet tool developed by Kaplan et al. (2016) was used to calculate participants'

delay discounting rate k. In this research, the Monetary Choice Questionnaire showed an acceptable internal consistency with a Cronbach's α of 0.94.

Procedure

Participants were asked to scan the QR code linking to the survey on Qualtrics, SurveyCircles and SONA, and answer questionnaires with their phones. They were informed of the duration (approximately 6 minutes) and the brief theoretical background of the study. Before they could enter the survey, participants   were provided with information about the study was provided and were asked to explicitly give their informed consent. It only proceeded if '*Yes*' was chosen; if '*No*' was chosen, they would be automatically directed to the end of the survey with a thank-you note. After having given informed consent, participants were asked about their age, current education level, and nationality. Then they were asked to fill in the questionnaire of 42 questions in total including one random response detection item "*Would you prefer: (a) $78 today; (b)$5 in 15 days*" in the end. Participants were asked to share the link with their social network at the end of the survey. The text was as follows: *"Please share the survey link with others to support our study! Your help will be highly appreciated."*

Statistical analyses

The data was retrieved from the survey at Qualtrics. When exporting it, the participants who didn't provide consent ($N = 1$) and who failed to answer the detect question ($N = 39$) were excluded (by doing that we also filtered the incomplete cases since the detect question was at the end of the questionnaire). Then 115 cases were exported to and analyzed by R 2023.12.1+402.

The variable recoding was performed, transforming scale items into numbers, including reverse scoring if necessary. The mean score of the nine items on the Bedtime Procrastination Scale (BP) was used as the measure of bedtime procrastination. For sleep health, the total score of the five items on the Satisfaction, Alertness, Timing, Efficiency and Duration Questionnaire questionnaire was utilized as the measure of sleep health (SH). Then, mean, standard deviation, or portion were

conducted to describe participants' features, including age, nationality, and current education level. Then one participant with age above 100 was excluded. Data cleaning on the response times was conducted. The bottom 5% of cases with the shortest response times (less than 154.45 seconds), totaling 6 cases, were removed. Then K values were calculated using the tool developed by Kaplan et al. (2016) and participants with unreliable overall consistency below 75% were excluded (N = 2) accordingly. The final dataset comprised 106 cases.

The internal consistency reliability of scales used in the study was evaluated using Cronbach's α on the Bedtime Procrastination Scale and the Monetary Choice Questionnaire. Internal consistency of the Satisfaction, Alertness, Timing, Efficiency and Duration Questionnaire was not calculated due to the fact that there are only five questions, one for each dimension, measuring different constructs, therefore it was not reasonable to internal consistency. Preliminary analyses included testing for normality using the Kolmogorov-Smirnov test, QQ plot (with k logarithmically transformed as $\log k$), and checking multicollinearity with VIF. Homoscedasticity was tested with Levene's test to ensure consistent residual variances across predictor levels. Descriptive statistics were then computed to summarize the characteristics of each study variable. Finally, a mediation analysis was conducted using the PROCESS macro by Hayes (2022), Model 4, utilizing 5,000 bootstrap samples to estimate bias-corrected confidence intervals for indirect effects.

Results

Preliminary analysis

Normality. A Kolmogorov-Smirnov test was performed on bedtime procrastination and sleep health, where a small amount of random noise was added to variables using jitter() to address issues with duplicate values in the ranking process. Results showed that the distribution of bedtime procrastination ($D = 0.05$, $p = 0.93$) and sleep health ($D = 0.09$, $p = 0.28$) both followed a normal distribution (see Figure 3). Delay discounting parameter k was logarithmically transformed ($\log k$) to normalize its distribution and meet the assumptions of linear regression analysis. The

QQ plots suggested that assumptions of normality are reasonable for further statistical analyses involving these variables (see Figure 4).

Figure 3

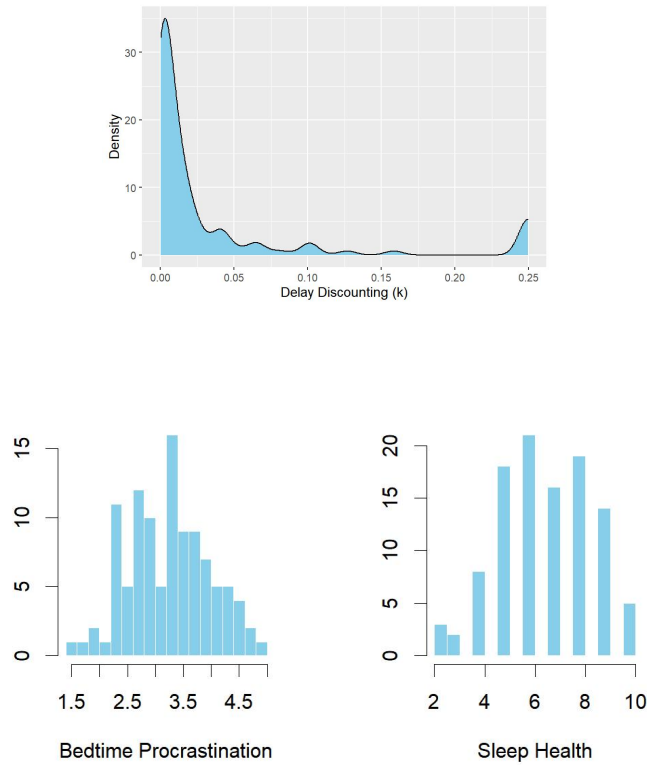*Distribution of Delay Discounting, Bedtime Procrastination and Sleep Health*
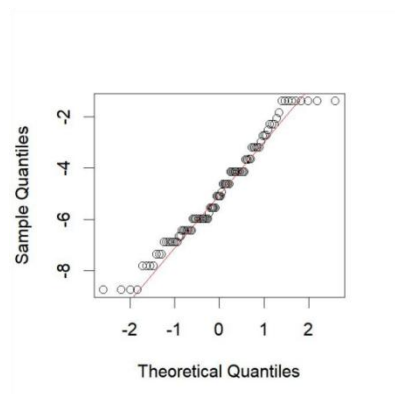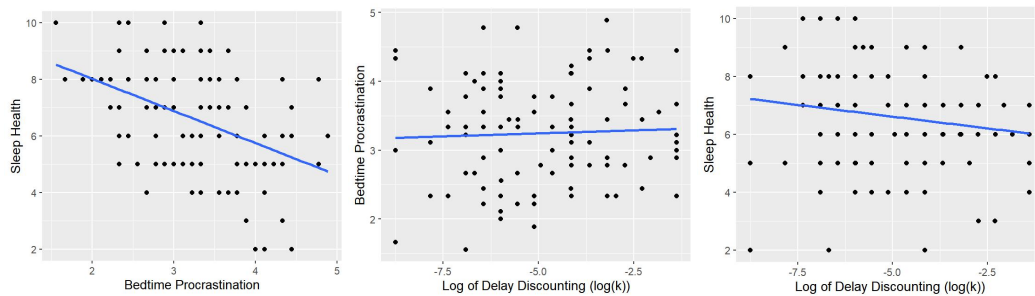

Figure 4

QQ Plot of Delay Discounting ($\log k$)

Linearity. QQ plots were used to depict the linear relationships between variables, as shown in Figure 5, where pairwise linear correlations among variables are illustrated.

Figure 5

Variables' Pairwise Linear Relationships

Multicollinearity. The variance inflation factor (VIF) values were examined to assess multicollinearity among the variables. The VIF values for the delay discounting (k and $log\,k$) and bedtime procrastination were both approximately 1.00, indicating no significant multicollinearity issues among the variables.

Homoscedasticity. The homogeneity of variance assumption was assessed using Levene's test. The results indicated that the variances differed significantly for Sleep Health ($F(3, 102) = 2.82$, $p = 0.04$), suggesting violation of homogeneity of variances. However, for bedtime procrastination, the variances did not significantly differ ($F(3, 102) = 0.54$, $p = 0.65$), indicating homogeneity of variances.

Outliers. Outliers were assessed for variables sleep health and bedtime procrastination using the 3 IQR rule (Hoaglin & Iglewicz, 1987). No outliers were identified for either variable.

Descriptive analysis

The descriptive statistics and Pearson's correlations for the study variables are presented in Table 2. Results revealed a significant negative correlation between delay discounting (k) and sleep health ($r = -0.216$, $p = 0.02$). Similarly, bedtime procrastination showed a stronger negative correlation with sleep health ($r = -0.437$, $p < 0.001$).

Table 2

Descriptive statistics and Pearson's correlations of study variables (N = 106)

	M	*SD*	1	2	3	4
1. *k*	.037	.070	__			
2. *log k*	-4.932	1.938	.763	__		
3. Bedtime procrastination [a]	3.246	.730	.018	.046	__	
4. Sleep health [b]	6.604	1.890	-.216*	-.166	-.437***	__

* Correlation is significant at the 0.05 level (2-tailed).

*** Correlation is significant at the 0.001 level (2-tailed).

[a] 1 = (almost) never, 5 = (almost) always

[b] 0 = rarely/never, 1 = sometimes, 2 = usually/always

Mediation analysis. Model 4 of the PROCESS macro was used to examine the mediating effect of bedtime procrastination on the relationship between delay discounting and sleep health, with bootstraps set as 5000. Table 3, Table 4, and Figure 6 present the results of the mediation model. Delay discounting (k) significantly negatively predicted sleep health (β = -5.55, p = 0.017, path c'). When bedtime procrastination was considered as a mediator, delay discounting (k) did not significantly predict bedtime procrastination (β = 0.19, p = 0.84, path a); but bedtime procrastination had a negative predictive effect on sleep health (β = -1.12, p < 0.001, path b). As presented in Table 4, the direct effect of delay discounting on sleep health was significant (β = -5.55, p = 2.30, 95% *CI* [-10.12, -0.98]), as the 95% *CI* did not include zero; while the indirect effect via bedtime procrastination was insignificant (β = -0.21, p = 0.99, 95% *CI* [-2.35, 1.60]), as the 95% *CI* included zero. Therefore, H1 was supported, indicating a significant negative prediction of delay discounting on sleep health. However, H 2 did not receive support, as bedtime procrastination did not significantly mediate the relationship between delay discounting and sleep health.

Table 3

Mediation analysis results

Antecedent		M (Bedtime procrastination)				Y (Sleep health)		
		β	SE	p		β	SE	p
X (k)	a	0.19	1.01	0.84	c'	-5.55	2.30	0.017
M (Bedtime procrastination)					b	-1.12	0.22	< .001
Constant		10.42	0.77	0.000				
		R^2	0.000			$R^2 = 0.23$		

Table 4

Mediation analysis summary of Delay discounting (k)

Effect	Path	β	SE	95%CI Lower	95%CI Upper	t	p
Total	Delay discounting (k) → Sleep health	-5.77	-	-	-	-	-
Indirect	Delay discounting (k) → bedtime procrastination → Sleep health	-0.21	0.99	-2.35	1.60	-	-
Direct	Delay discounting (k) → Sleep health	-5.55	2.30	-10.12	-0.98	-2.35	0.020*

* Effect is significant at the 0.05 level (2-tailed).

Figure 6

Path diagram of the mediation model
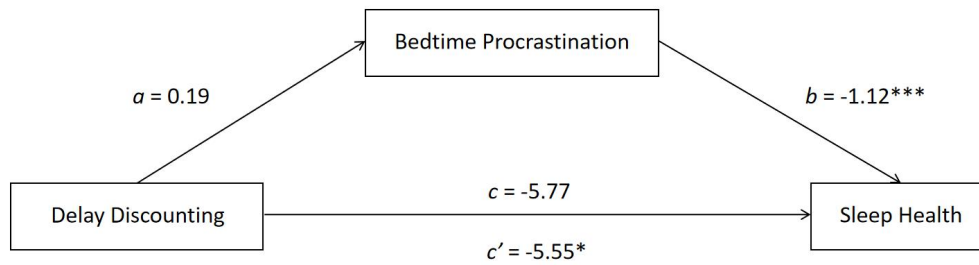
* Effect is significant at the 0.05 level (2-tailed).

*** Effect is significant at the 0.001 level (2-tailed)

Discussion

The aim of this study was to investigate the impact of delay discounting on sleep health and to determine whether this effect is mediated by bedtime procrastination. The results indicate that delay discounting adversely affects sleep health, as expected. However, contrary to expectations, bedtime procrastination did not serve as a mediator in this relationship. Specifically, no significant correlation was detected between delay discounting and bedtime procrastination. However, there was a significant negative relationship between bedtime procrastination and sleep health. This finding aligns with existing research suggesting that individuals who favor immediate rewards over delayed benefits tend to engage in behaviors that compromise their health in general, including sleep health (Felton et al., 2020). The absence of a significant relationship between delay discounting and bedtime procrastination suggests that the tendency to prefer immediate rewards does not necessarily translate into procrastinating sleep. This contradicts some theories that posit a direct link between impulsive decision-making and procrastination behaviors (Gustavson et al., 2014; Steel, 2007). However, the strong negative relationship between bedtime procrastination and sleep health is consistent with previous research (Hill et al., 2022; Li et al., 2020), highlighting the detrimental effects of delaying sleep on overall sleep quality and health.

Several studies have indicated a relationship between delay discounting and procrastination behavior (Steel, 2007; Zentall, 2021; Sasaki et al., 2008). However, this phenomenon was not confirmed in the present study. Despite the insignificant mediating model, it is premature to completely dismiss the potential role of delay discounting in bedtime procrastination. The relationship may be more complex than initially anticipated. A possible explanation is that bedtime procrastination may arise from different underlying mechanisms and is not solely a short-sighted behavior. According to Nauts et al. (2019), there are three types of bedtime procrastination: deliberate procrastination, where individuals knowingly and intentionally delay sleep; mindless procrastination, where individuals lose track of time without abandoning

their intention to regulate sleep time, often due to distraction and inattention; and strategic procrastination, where individuals use procrastination to cope with sleep-related situations. Although deliberate procrastination may balance short-term pleasure against long-term sleep health concerns, the latter two types, in particular, suggest the relationship between delay discounting and bedtime procrastination may be more complex.

One potential factor is chronotype, which is linked to variations in arousal levels and cognitive performance throughout the day- and evening-types. The latter tend to be most alert and active during the evening hours and report optimal functioning during this time (Fabbri et al., 2013). This increased evening performance may make them more prone to engaging in various pre-sleep activities. Moreover, evening-types perceive future temporal expressions as occurring in a more distant future (Beracci et al., 2022), which might lead to an overestimation of the time interval until sleep when they engage in pre-sleep activities. This, in turn, could indicate a propensity to delay the obligation of keeping scheduled bedtime despite their subjective willingness. Therefore, adding chronotype as a moderator between delay discounting and bedtime procrastination, the model may gain enhanced explanatory power. Moreover, building up sleep pressure to achieve more efficient sleep onset is considered the goal for strategic procrastinators. This intentional behavior suggests it aligns more with strategic delay rather than a form of procrastination that falls outside the scope of this study. Therefore, it is preferable to exclude the impact of strategic procrastination. Given the challenge of directly identifying strategic procrastinators, a practical approach would involve using perceived sleep pressure as an indirect control variable in the analysis.

Strength and limitations

First, this study has a very comprehensive perspective, using sleep health, which measures the overall effect, to describe sleep behavior from a macroscopic perspective, complementing previous research in the field of sleep. Second, the present study is groundbreaking in that it is the first to examine the effect of delay

discounting as a predictor variable on sleep health, partially confirming the proposed hypotheses of previous studies (Massar, 2019), which helps reveal the possible bi-directional relationship between decision-making and sleep.

However, this study still has its limitations. The Bedtime Procrastination Scale (Kroese et al., 2014) utilized in this study may not fully capture all aspects of sleep procrastination. This scale is a measure of bedtime procrastination, which involves delaying the initiation of sleep routines. However, sleep procrastination also encompasses in-bed procrastination, where individuals delay falling into sleep even after getting into bed (Magalhães et al., 2020). The exclusion of in-bed procrastination from our assessment may have limited our understanding of how delay discounting influences behaviors that occur after the bedtime routine has started. Besides, despite the Monetary Choice Questionnaire (Kirby et al., 1999) being the sole questionnaire used to measure delay discounting, the use of monetary rewards to assess delay discounting tendencies in this study raises concerns about ecological validity. Recent research (Rasmussen et al., 2024) suggests that nonmonetary outcomes, such as food, drugs, or sexual outcomes, may more accurately reflect discounting rates in health-related contexts. Participants are more sensitive to the delay of these nonmonetary outcomes, as often discounted more steeply than monetary rewards in specific domains, including behaviors related to sleep. Therefore, the reliance on monetary rewards in our study may not fully reflect the decision-making processes that happen in procrastination of sleep. What's more, this study did not screen participants for clinical sleep disorders, which could potentially affecting sleep health, covering the decrease of sleep health caused by impulsive decision-making tendency and sleep procrastination. Undiagnosed sleep disorders might lead participants to involuntarily delay sleep (e.g., strategic procrastination, using bedtime procrastination as a coping method for difficulty in falling asleep), thereby impacting their overall sleep hygiene.

Recommendations for Future Study

Future studies could further the examination by refining measures, applying more strict controlled conditions, and expanding the scope of the model. First, more validity measures of delay discounting are recommended. Future research could explore the appropriate nonmonetary rewards for studying delay discounting in the context of sleep, for example, an extra short break, and incorporate these findings into their methodologies. By identifying non-monetary rewards that are directly related to sleep behaviors and have higher ecological validity, future research could provide a more accurate understanding of how delay discounting affects bedtime procrastination and related health outcomes in real life. Besides, an alternative measure other than delay discounting is also proposed, delay of gratification, which is an index of impulsive behavior as well as delay discounting. Delay of gratification is the ability to sustain a choice for a preferred, but delayed, reward, without giving in to temptations in the waiting for future rewards (Reynolds & Schiffbauer, 2005), in other words, not a one-time thing. It is related to delay discounting in the feedback model of delay-related impulsive behavior (Reynolds & Schiffbauer, 2005). To be specific, delay discounting is considered more of a learning-mediated process from the feedback of delay of gratification process. Delay of gratification reflects one's behavior inhibition and through the execution of behavior inhibition, people incorporate the persistence (if so) to their subjective measurement of choice preference. In real life, people need to make consistent efforts to maintain good sleep health, which seems a long choice-reward period – we think the occasional breaking of sleep regulation is not a big deal. However, one needs to continue to say no to pre-sleep temptations, and the choice preference between appropriate sleep timing and instant leisure (delay discounting) could be a result of the long-term temptation. Therefore, it would be a good way to include delay of gratification into the model or as an alternative measure of delay-related impulsive behavior to reveal the mechanism more deeply of both choice preference and ability to sustain a choice in the sleep domain. Future research could address this limitation by including screening measures

for sleep disorders among participants to better uncover the impact of delay discounting tendency on sleep behaviors and outcomes.

As for the potentially complex relationship indicated by the missing correlation of delay discounting and bedtime procrastination, chronotype is suggested to be added as a moderator in investigating the relationship in people of different chronotypes. By doing so, how influential biological and genetic factors are in the relationship can be assessed, and further answer the question of whether delay discounting interferes with sleep health via sleep procrastination. Additionally, controlling for clinical sleep disorders can minimize their influence, enabling a clearer exploration of the behavioral relationship between delay discounting and sleep procrastination. Moreover, if interested in a broad scope of impulsive behavior's effect on procrastination in general sleep-related behavior, in-bed procrastination can be incorporated together with bedtime procrastination in the study. This will provide a more comprehensive understanding of sleep procrastination behaviors.

Theoretical and Practical Implications

This study validates theories suggesting that impulsive decision-making can undermine health outcomes (MacKillop et al., 2011; Bickel et al., 2019), specifically in relation to sleep. By exploring how delay discounting influences bedtime procrastination and, consequently, sleep health, this research expands our understanding of decision-making processes in health behavior. It prompts scholars to reevaluate the impact of decision-making on behavior choices and encourages further exploration of underlying mechanisms.

What's more, the potential causal relationship of delay discounting to sleep health in this study suggests practical interventions by targeting delay discounting and improving sleep-related decisions. Situation strategies can be used to keep procrastinators away from temptations to make less short-sighted choices (e.g., asking a family member to keep your iPad away from you before sleep time). Implementation interventions (II) can also be helpful for individuals to cope with tempting situations by foreseeing and preparing solutions for them. Besides, direct techniques for reducing delay discounting can be promising as well, such as episodic

future thinking (EFT), mentally simulating the beneficial outcomes of good sleep to enhance awareness of the long-term benefits of sleep health (Göllner et al., 2018; Shevorykin et al., 2019). These applications highlight opportunities for targeted interventions to support healthier decision-making in sleep and improve overall well-being. These techniques can also be used as experimental interventions to test sleep improvement after a period of intervention, further examining the relationship between delay discounting and sleep health.

Conclusion

In summary, this study investigated how delay discounting affects sleep health and explored whether bedtime procrastination mediates this relationship. Results show that delay discounting negatively impacts sleep health in a direct path. Contrary to expectations, bedtime procrastination did not act as a mediator, suggesting potential complex interactions between decision-making processes and sleep behaviors. These findings emphasize the need for further research to better comprehend the dynamics between impulsive decision-making and sleep health, calling for informing interventions that aim at improving sleep hygiene and overall health outcomes by targeting decision-making tendencies.

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Information Letter

Information about the Research Project

The title of the study is Instant Enjoyment above Sleep: A Cross-sectional Study on the Relationship between Delay Discounting and Sleep Health with the Mediating Role of Bedtime Procrastination.

Bedtime procrastination is the volitional delay of going to bed, without any legitimate reasons (e.g., night shift). It can be problematic to one's sleep duration, sleep quality and daytime fatigue etc.. However, people keep procrastinating sleep even if they can foresee the negative consequences. In this study, we look into people's preference between small instant reward and bigger but later reward, and see how this tendency affect bedtime procrastination and furthermore, sleep health. The study aims to answer questions as (1) what is the relationship between delay-discounting and sleep health; (2) if there is a relationship, can it be explained by bedtime procrastination as a mediator?

The main researcher for this study is Kexin Zhang, a master's student in the Health Promotion track within the Department of Social and Health Psychology at Utrecht University. For inquiries, the researcher can be contacted via email at k.zhang6@students.uu.nl.

Data access and processing will be overseen solely by the main researcher, Kexin Zhang. Prf. Laura A. Weiss serves as the first supervisor, while Dr. Wieby Altink-Van den Berg serves as the second supervisor for this study, both of them providing guidance, oversight, and mentorship to the primary researcher. The research has no funder.

This information is updated on March 24, 2024.

Information about participation

In our research project, data subjects play a crucial role in contributing valuable information. The tasks of the study is research survey, asking participants

to respond to 3 questionnaires. The duration of a data subject's involvement may vary individually, the average of which is 5 minutes in total.

Engaging in this research project offers several potential advantages, such as contributing to advancing understanding in a particular field, and gaining insights into their own behaviors or attitude.

No potential risks and unpleasant aspects are foreseen.

The application of the ethical committee for this research has been approved under the UU-SER approval number 24-0676.

Information about privacy

How Your Data Will Be Handled

The legal basis for processing the personal data of our respondents is their explicit consent. They are asked to consent to our data processing policy before participating in the survey.

Personal data including gender, age, highest finished education level, dutch or non-dutch, will be collected with explicit consent. The reason for collecting personal data is to control these individual variables for subsequent data processing, thereby eliminating their influence on the dependent variables.

Upon receipt of the data, anonymization will be carried out, with only the principal investigator having access to the raw data. Raw identifiable data will be securely stored throughout the research project to facilitate data analysis and effectively address research inquiries. This data will be maintained in a secure and encrypted format, accessible solely to authorized personnel involved in the research. The storage of raw identifiable data is solely for the purpose of fulfilling the research objectives outlined in the project. It is anticipated that there will be no data sharing or reuse.

Data subjects' rights

1. Participation in the study is completely voluntary and participants may choose to stop participating at any time. Decision to withdraw from the study at any time will not cause any possible negative consequences.

2. Participants have the right to be informed about how their personal data will be processed, including the purpose and scope of data collection and usage.

3. Participants have the right to access their personal data collected during the research project. They can request correction or modification of any inaccurate or incomplete information.

4. Participants have the right to limit the processing of their personal data under certain circumstances. They can request restrictions on how their data is used or processed.

5. Participants can exercise their rights regarding their data by contacting the main researcher. They can do so by emailing k.zhang6@students.uu.nl. The main researcher will facilitate any requests related to accessing, correcting, limiting processing, or withdrawing consent for personal data.

6. Participants can contact the ethical committee (if applicable) for questions about the set-up of your project, and that they can contact you, the UU's privacy department (privacy@uu.nl) or the Data Protection Officer of the UU (fg@uu.nl) – in that order – for exercising their rights and for questions and complaints. Participants have the right to file a complaint with the Data Protection Authority (Autoriteit Persoonsgegevens).

Informed Consent

Title of Study: The Impact of Delay Discounting on Sleep Health: the Mediation of Sleep Procrastination

Investigator(s): Kexin Zhang

Introduction

You are being invited to participate in a research study. Before you decide whether or not to participate, it is important for you to understand why the research is being done, what your participation will involve, and what risks and benefits may be associated with your participation.

Purpose of the Study

The aim of this study is to explore the role of sleep procrastination as a mediator between delay discounting and sleep health. Delay discounting refers to the tendency to choose immediate rewards over larger delayed rewards. This research seeks to understand how this decision-making process may impact sleep health and whether sleep procrastination serves as a mediator in this relationship in university students. Your participation will help uncover the potential mechanisms linking decision-making tendencies and sleep behaviors, contributing to insights for promoting better sleep habits.

Procedures

If you agree to participate, you will be asked to fill in 3 questionnaires in a certain order, with 42 questions in total, which will take approximately 6 minutes.

Risks and Benefits

While we have taken care to anticipate and minimize potential risks in this study, no specific risks have been identified as inherent to your participation. Your involvement in this research is designed to be low-risk and non-invasive. However, any discomfort or concerns arising during the study can be addressed promptly by contacting k.zhang6@students.uu.nl.

Several potential benefits associated with participation in this study are (1) your participation will contribute to expanding knowledge in this field; (2) you may gain insights into your own sleep habits and decision-making processes; (3) the study's findings could have positive implications for understanding and improving sleep health.

Confidentiality

Your participation in this study will be kept confidential to the extent allowed by law. All data collected during the study will be stored in a secure location and only accessed by authorized personnel. Your name and other identifying information will not be included in any reports or publications resulting from this study.

Voluntary Participation

Your participation in this study is completely voluntary. You have the right to withdraw from the study at any time without penalty. If you choose not to participate or if you withdraw from the study, there will be no negative consequences.

Rights on personal data

1. Right to Information: You have the right to be informed about how your personal data will be processed, including the purpose and scope of data collection and usage.

2. Right to Access and Rectification: You have the right to access your personal data collected during the research project. You can request correction or modification of any inaccurate or incomplete information.

3. Right to Limit Data Processing: You have the right to limit the processing of your personal data under certain circumstances. You can request restrictions on how your data is used or processed.

Contact Information

If you have any questions or concerns about the study, you can contact the investigator(s) at k.zhang6@students.uu.nl. If you have questions about your rights as a research participant, you may contact Ethics Review Board of the Faculty of Social & Behavioural Sciences | Universiteit Utrecht (uu.nl).

You can contact the ethical committee for questions about the set-up of this study. You can contact the investigator, the UU's privacy department (privacy@uu.nl) or the Data Protection Officer of the UU (fg@uu.nl) – in that order – for exercising your rights and for questions and complaints. You also have the right to file a complaint with the Data Protection Authority (Autoriteit Persoonsgegevens).

Statement of Consent

By signing below, you acknowledge that you have read and understood the information provided in this consent form and that you freely and voluntarily consent to participate in this study.

Participant Signature: _____ Date: _____

Appendix C

Delay discounting & sleep health

Q58 **Welcome to our Sleep Study: Unraveling the Mysteries of Your Rest**   Have you ever found yourself pressing the snooze button repeatedly, delaying bedtime, or struggling to prioritize a good night's sleep? You're not alone. In today's fast-paced world, where time is a precious commodity, our sleep health often takes a backseat. But have you ever wondered how your tendency to prioritize immediate rewards over delayed gratification impacts your sleep quality? We invite you to take part in an exciting exploration of "The Impact of Delay Discounting on Sleep Health: the Mediation of Sleep Procrastination," unveiling the factors influencing your sleep habits and overall well-being.
Your involvement in this research is voluntary and designed to be low-risk and non-invasive. You have the right to withdraw from the study at any time without penalty. Your responses will be kept confidential, and all data will be anonymized for analysis purposes. Your participation will contribute to cutting-edge research in the field of sleep psychology. If any discomfort or concerns arise during the study, you may contact our researcher at k.zhang6@students.uu.nl.

By ticking the box below, you acknowledge that you have read and understood the information provided in this consent form and that you freely and voluntarily consent to participate in this study.

- -

Q59 I consent to participate in this study.

○ Yes   (1)

○ No   (2)

Skip To: End of Survey If I consent to participate in this study. = No

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Q61 What is your age? (in years, e.g. 25)

_____

Q62 Please indicate your gender

○ Female   (1)

○ Male   (2)

○ Non-binary / third gender   (3)

○ Prefer not to say   (4)

○ Other   (5) _____

Q63 What is your nationality?

_____

Q64 What year are you in?

○ Undergraduate (Bachlors)   (1)

○ Masters   (2)

○ PhD   (3)

○ Other (please specify)   (4)

_____

End of Block: Block 4

Start of Block: Block1

Q67 In this section, you'll be asked to reflect on your **bedtime habits**. Please select the response that best reflects your experiences. There are no right or wrong answers; feel free to give your genuine responses.

Q1 1. I go to bed later than I had intended.

○ Never   (1)

○ Sometimes   (2)

○ About half the time   (3)

○ Most of the time   (4)

○ Always   (5)

Q2 2. I go to bed early if I have to get up early in the morning.

○ Never   (1)

○ Sometimes   (2)

○ About half the time   (3)

○ Most of the time   (4)

○ Always   (5)

Q3 3. If it is time to turn off the lights at night I do it immediately.

○ Never   (1)

○ Sometimes   (2)

○ About half the time   (3)

○ Most of the time   (4)

○ Always   (5)

Q4 4. Often I am still doing other things when it is time to go to bed.

○ Never   (1)

○ Sometimes   (2)

○ About half the time   (3)

○ Most of the time   (4)

○ Always   (5)

Q5 5. I easily get distracted by things when I actually would like to go to bed.

○ Never   (1)

○ Sometimes   (2)

○ About half the time   (3)

○ Most of the time   (4)

○ Always   (5)

Q6 6. I do not go to bed on time.

○ Never   (1)

○ Sometimes   (2)

○ About half the time   (3)

○ Most of the time   (4)

○ Always   (5)

Q7 7. I have a regular bedtime which I keep to.

○ Never   (1)

○ Sometimes   (2)

○ About half the time   (3)

○ Most of the time   (4)

○ Always   (5)

Q8 8. I want to go to bed on time but I just don't.

○ Never   (1)

○ Sometimes   (2)

○ About half the time   (3)

○ Most of the time   (4)

○ Always   (5)

Q9 9. I can easily stop with my activities when it is time to go to bed.

○ Never   (1)

○ Sometimes   (2)

○ About half the time   (3)

○ Most of the time   (4)

○ Always   (5)

Q66 In this section, you'll be asked to reflect on various aspects of your **sleep experience**. Please select the response that best reflects your experiences.
There are no right or wrong answers; feel free to give your genuine responses.

Q10 1. Are you satisfied with your sleep?

○ Rarely / Never   (1)

○ Sometimes   (2)

○ Usually / Always   (3)

Q11 2. Do you stay awake all day without dozing?

○ Rarely / Never   (1)

○ Sometimes   (2)

○ Usually / Always   (3)

Q12 3. Are you asleep (or trying to sleep) between 2.00 a.m. and 4.00 a.m.?

○ Rarely / Never   (1)

○ Sometimes   (2)

○ Usually / Always   (3)

Q13 4. Do you spend less than 30 minutes awake at night?   *(This includes the time it takes to fall asleep and awakenings from sleep.)*

○ Rarely / Never   (1)

○ Sometimes   (2)

○ Usually / Always   (3)

Q14 5. Do you sleep between 6 and 8 hours per day?

○ Rarely / Never   (1)

○ Sometimes   (2)

○ Usually / Always   (3)

End of Block: Block 2

Start of Block: Block 3

Q65 In this section, imagine scenarios where you'll receive an amount of money as a reward. You'll have to choose between receiving a **smaller** amount of money **today** or a **larger** amount **in a certain number of days**.
Remember, there are no right or wrong answers—just choose what feels best for you.

Q15 1. Would you prefer

     ○ (a) $54 today   (1)

     ○ (b) $55 in 117 days   (2)

Q16 2. Would you prefer

     ○ (a) $55 today   (1)

     ○ (b) $75 in 61 days   (2)

Q17 3. Would you prefer

     ○ (a) $19 today   (1)

     ○ (b) $25 in 53 days   (2)

Q18 4. Would you prefer

     ○ (a) $31 today   (1)

     ○ (b) $85 in 7 days   (2)

Q19 5. Would you prefer

     ○ (a) $14 today   (1)

     ○ (b) $25 in 19 days   (2)

Q20 6. Would you prefer

    ○ (a) $47 today   (1)

    ○ (b) $50 in 160 days   (2)

Q21 7. Would you prefer

    ○ (a) $15 today   (1)

    ○ (b) $35 in 13 days   (2)

Q22 8. Would you prefer

    ○ (a) $25 today   (1)

    ○ (b) $60 in 14 days   (2)

Q23 9. Would you prefer

    ○ (a) $78 today   (1)

    ○ (b) $80 in 162 days   (2)

Q24 10. Would you prefer

    ○ (a) $40 today   (1)

    ○ (b) $55 in 62 days   (2)

Q25 11. Would you prefer

○ (a) $11 today (1)

○ (b) $30 in 7 days (2)

Q26 12. Would you prefer

○ (a) $67 today (1)

○ (b) $75 in 119 days (2)

Q27 13. Would you prefer

○ (a) $34 today (1)

○ (b) $35 in 186 days (2)

Q28 14. Would you prefer

○ (a) $27 today (1)

○ (b) $50 in 21 days (2)

Q29 15. Would you prefer

○ (a) $69 today (1)

○ (b) $85 in 91 days (2)

Q30 16. Would you prefer

○ (a) $49 today   (1)

○ (b) $60 in 89 days   (2)

Q31 17. Would you prefer

○ (a) $80 today   (1)

○ (b) $85 in 157 days   (2)

Q32 18. Would you prefer

○ (a) $24 today   (1)

○ (b) $35 in 29 days   (2)

Q33 19. Would you prefer

○ (a) $33 today   (1)

○ (b) $80 in 14 days   (2)

Q34 20. Would you prefer

○ (a) $28 today   (1)

○ (b) $30 in 179 days   (2)

Q35 21. Would you prefer

   ○ (a) $34 today   (1)

   ○ (b) $50 in 30 days   (2)

Q36 22. Would you prefer

   ○ (a) $25 today   (1)

   ○ (b) $30 in 80 days   (2)

Q37 23. Would you prefer

   ○ (a) $41 today   (1)

   ○ (b) $75 in 20 days   (2)

Q38 24. Would you prefer

   ○ (a) $54 today   (1)

   ○ (b) $60 in 111 days   (2)

Q39 25. Would you prefer

   ○ (a) $54 today   (1)

   ○ (b) $80 in 30 days   (2)

Q40 26. Would you prefer

○ (a) $22 today   (1)

○ (b) $25 in 136 days   (2)

- -

Q41 27. Would you prefer

○ (a) $20 today   (1)

○ (b) $55 in 7 days   (2)

- -

Q42 28. Would you prefer

○ (a) $78 today   (1)

○ (b) $5 in 15 days   (2)

Q70 **Please share the survey link with others to support our study! Your help will be highly appreciated.**

If you are not a SurveyCircle user, please ignore the following.

Users of the research platform SurveyCircle.com will receive SurveyCircle points for their participation. The Survey Code is: **MTX4-6DNV-HG58-K1X6**

To Redeem the Survey Code with one click:
https://www.surveycircle.com/MTX4-6DNV-HG58-K1X6/