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Investigating the role of goal motives in predicting bedtime procrastination using a daily diary study design: a registered report

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ABSTRACT

Objectives: Previous operationalisations of bedtime procrastination were incongruent with its definition. We addressed this gap in knowledge by testing a new operationalisation that incorporates the three necessary and sufficient conditions of bedtime procrastination. We investigate the motivational antecedents of bedtime procrastination in daily life with this new operationalisation.

Methods and Measures: Participants ($n = 336$) self-reported goal motives, chronotype, and typical sleep metrics on a Sunday evening. For the following 7-days, participants self-assessed their 24-h sleep metrics, goal-regulatory variables, and psychological needs.

Results: The bedtime discrepancy scores from the new assessment correlate in expected direction with sleep quantity and chronotype. However, our findings pertaining to motivational correlates of bedtime procrastination showed low compatibility with our expectations.

Discussion: We introduced a new operationalisation of bedtime procrastination that aligns with its definition, and which can complement existing approaches that primarily encompass trait-like elements. Incorporating all three necessary and sufficient conditions of bedtime procrastination at the daily level suggests previous prevalence estimates of this sleep-related behaviour obtained with trait-like operationalisations may be overestimated. The low compatibility between our expectations regarding the motivational antecedents of bedtime procrastination suggest a need for congruence between the levels at which antecedents are captured with this sleep-related behaviour.

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Bedtime procrastination; goal motives; goal-regulatory variables; psychological needs; self-concordance model

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Introduction

A 75-year-old healthy adult who consistently sleeps 7–9 h per 24-h cycle would have spent around 25 years of their entire life sleeping. The sheer amount of time we invest in sleeping sufficiently represents one of the biggest returns on investment for our health and well-being (Afolalu et al., 2018; Scott et al., 2021). However, many people fail to meet the recommended guidelines for sleep (Hirshkowitz et al., 2015; Ohayon et al., 2017), which places them at risk for numerous maladaptive outcomes, including cardiovascular diseases and type 2 diabetes (e.g. Cappuccio et al., 2010; Ge & Guo, 2015; Krittanawong et al., 2019; Pires et al., 2016). Finding effective ways to encourage and maintain sleep health—the balance of sleep and wakefulness that is tailored to meet individual, social, and environmental demands (Buysse, 2014)—remains a pressing scientific challenge.

The transition from wakefulness to sleep is a critical intervention period. Going to sleep at a reasonable time that makes one feel fully rested can be problematic for many people. For example, among a representative sample of the Dutch population ($n = 2431$), 53% of the participants reported delaying going to sleep at their intended bedtime, at least two or more days of the week, mostly because of activities such as watching TV and using devices (Kroese et al., 2016). This discrepancy between one's intended and actual bedtime is referred to as bedtime procrastination (Kroese et al., 2014). Specifically, bedtime procrastination is defined as 'needlessly and voluntarily delaying going to bed, despite foreseeably being worse off as a result' (Kroese et al., 2016, p. 102). Bedtime procrastination has been found to be positively associated ($.28 < r < .61$) with daytime fatigue and insufficient sleep (Kroese et al., 2016; Kroese et al., 2014) and negatively associated ($-0.19 < r < -0.38$) with sleep quality and sleep quantity (Bernecker & Job, 2020; Hill et al., 2022). With regard to individualistic qualities, a recent meta-analysis (Hill et al., 2022) found a moderate association between bedtime procrastination and chronotype, which refers to differences between individuals in their preferences for when to go to bed and wake up. Specifically, individuals with evening chronotype (those who prefer going to sleep late and waking up late) tend to procrastinate their bedtime more, compared to individuals with a morning chronotype (Chung et al., 2020; Kadzikowska-Wrzosek, 2018, 2020). Thus, efforts to understand and address bedtime procrastination represent an important line of inquiry to improve sleep health.

Differentiating procrastination from other reasons for sleep delay

By definition, procrastination is a behavioural act in which one delays doing an intended action, despite an expectation of being worse off (Steel, 2007, p. 66). The reasons people might procrastinate regarding their bedtime can be broadly categorised as deliberate or mindless in nature (Nauts et al., 2019). Deliberate procrastination involves trading a portion of one's sleep duration to gain free personal time after a taxing day, even when one expects to be worse off by sleeping less. Conversely, mindless procrastination occurs when individuals become distracted and lose track of time (e.g. scrolling through TikTok). Defining bedtime procrastination as a voluntary behaviour differentiates it from other causes of delaying sleep that may be

unavoidable (e.g. unexpected guests). Additionally, some delays of sleep may be perceived as adaptive. Strategic delays, whereby individuals purposefully postpone going to sleep because they genuinely think that doing so will do more good than harm, cannot be categorised as procrastination (Nauts et al., 2019). For instance, delaying bedtime would be considered as strategic delay if the person is emotionally charged after an argument with their romantic partner, so they take some time off to 'cool down' rather than lying in bed ruminating about the event and struggling to fall asleep. Strategic delay cannot be considered bedtime procrastination as, by definition, one needs to acknowledge that the delay was needless and unwarranted, and likely to place them in a position where they are worse off (Kroese et al., 2016; Nauts et al., 2019). Similarly, external events that cause unavoidable delays in bedtime cannot be considered bedtime procrastination (e.g. a house party next door with loud noise). To date, however, these conceptual distinctions between procrastination and external reasons for sleep delay remain largely overlooked in the operationalisations that researchers have used to study bedtime procrastination. We address this limitation in the current study by probing for the rationale for one's bedtime delay.

Maximising congruence between the definition and operationalisation of bedtime procrastination represents an important consideration for research in the field. The definition of bedtime procrastination described above encompasses three criteria for bedtime procrastination: delayed sleep, lack of a valid reason to delay sleep, and expectation to be worse off due to delaying sleep. The modus operandi for assessing bedtime procrastination—the Bedtime Procrastination scale (Kroese et al., 2014)—insufficiently captures these necessary conditions of bedtime procrastination. Items contained within this self-report tool capture one's perception of their general sleep habits (e.g. 'If it is time to turn off the lights at night, I do it immediately [R]') and focus solely on the delay aspect of bedtime procrastination, thereby making it is impossible to capture cases where there was a valid reason to delay sleep. Furthermore, self-reports *via* this scale capture mostly trait-like features of bedtime procrastination (Hill et al., 2022). Trait-like elements of bedtime procrastination offer limited insight, as there is substantial variation in daily bedtime procrastination levels (e.g. 75%; Kühnel et al., 2018). The second common way of measuring bedtime procrastination is to calculate a discrepancy score between the time participants reported intended to go to sleep and the actual time they went to sleep (e.g. Valshtein et al., 2020). Similar to the Bedtime Procrastination scale, discrepancy scores alone are unable to assess the necessary conditions for bedtime procrastination, as they provide no information on the reason of the delay and the degree to which participants expect to be better or worse off. Acknowledging these limitations, we define bedtime procrastination as a volitional or non-volitional delay of one's intended time for going to sleep that has no valid reason, and which one expects to leave them physically or psychologically deprived the next day[1].

Motivational forces involved in bedtime procrastination

Addressing procrastination for sleeping requires an understanding of the motivational factors underpinning the transitionary process from wakefulness to sleep. Interventions informed by self-determination theory (SDT; Ryan & Deci, 2017) have demonstrated

effectiveness for changing various health behaviours and improving health-related outcomes (e.g. Ntoumanis et al., 2021; Sheeran et al., 2020). Given the adverse outcomes of being sleep deprived, understanding the motivational dynamics and drivers of sleep procrastination could help tackle this health problem. Grounded in SDT, the self-concordance model (Sheldon & Elliot, 1999) distinguishes between autonomous and controlled forms of goal motivation and describes a pathway from these two goal motives to well-being *via* goal attainment. Goals pursued with autonomous motives reflect the interests and deeply seated values of a person and are considered 'self-concordant'. For example, someone who views themselves as a healthy person and values the benefits of being well-rested would be said to have autonomous motives for going to sleep on time. Meta-analytic path modelling ($N = 10{,}289$; 978 effects) of the self-concordance model indicated that autonomous goals are positively associated with the likelihood of goal attainment and optimal well-being ($r_{ind} = .09$; Sezer et al., 2024). Goals pursued with controlled motives, on the other hand, are harder to integrate within one's sense of self because they are driven by internal and external contingencies. For example, a person who aims to go to sleep on time because they feel guilty if they do not do so would be said to have controlled motives for avoiding bedtime procrastination. Meta-analytic evidence indicates goals pursued with controlled motives typically have lower rates of goal attainment ($r_{ind} = -.06$; Sezer et al., 2024). Kadzikowska-Wrzosek (2020) found a moderate-to-large negative association ($r_s = -.37$; using the effect size criteria by Funder & Ozer, 2019) between tendencies towards bedtime procrastination and autonomous motivation. This meta-analytic and empirical work, however, overlooks night-to-night variations in bedtime procrastination, which may be underpinned by both personal (e.g. self-regulation) and situational factors (e.g. house chores).

Inherent within the self-concordance model is a temporal sequence from the inception of goal selection to the respective outcomes associated with goal attainment. The process by which autonomous goal pursuit leads to higher goal attainment is proposed to occur through adaptive goal-regulation. For example, a person who goes to sleep on time for autonomous reasons is more likely to use effective strategies to regulate their behaviour (e.g. putting effort into actively managing their sleep routines), compared to someone who pursues the same goal for controlled reasons. Adaptive goal-regulatory variables encompass factors that maximise the likelihood of goal attainment. Goal effort is one such variable and is proposed to mediate the link between self-concordance and goal attainment in the SCM. Goal commitment is another goal-regulatory variable that deals with one's attachment or determination to attain a goal (Locke et al., 1988). Meta-analytic estimates (Gaudreau et al., 2012; Koestner et al., 2008; Sezer et al., 2024) support the mediating role of adaptive goal-regulatory variables in explaining the association between autonomous motivation and goal attainment. Notably, having autonomous reasons for goal pursuit is associated with sustained goal-regulation, whereas regulatory behaviour is more likely to wane over time for goals pursued with controlled motives (Riddell et al., 2022).

In addition to adaptive goal-regulation, attaining autonomous goals fulfills the universal needs proposed in the SDT which are suggested to be necessary for personal growth and well-being (Deci & Ryan, 2000). These needs are autonomy (i.e. having volition in one's actions), competence (i.e. being able to reach desired

outcomes), and relatedness (i.e. feeling connected to others). Meta-analytic findings indicate a positive association between autonomous goals and the satisfaction of psychological needs (r = .35), whereas pursuing controlled goals is negatively associated with the frustration of psychological needs (r = .36; Sezer et al., 2024). Furthermore, recent meta-analyses of the SDT literature supports a link between psychological needs and goal outcomes through autonomous and controlled motivation (Ryan et al., 2022; Sheeran et al., 2020; Vasconcellos et al., 2020). As the self-concordance model encapsulates the entire process from selecting goals that are congruent with a person's self to the outcomes of such goals (e.g. psychological need satisfaction), it represents a useful conceptual backdrop upon which to unpack bedtime procrastination dynamics.

Study aims and hypotheses

The first aim of the current study is to address the aforementioned methodological and conceptual gaps in the bedtime procrastination research. We propose an updated definition of bedtime procrastination that frames it as 'going to sleep' (instead of 'going to bed') and incorporates mindless cases of procrastination. Operationally, we used an enhanced assessment of bedtime procrastination that differentiates delays that fit the criteria for procrastination from those which do not. We classified the delays as valid cases of bedtime procrastination when participants had no reasonable alternative but to delay their bedtime and expected to be physically or psychologically deprived (e.g. fatigue, upset). We left out the cases that did not fit the criteria for bedtime procrastination (e.g. participants that do not expect to be sleep deprived the next day because it is the weekend). After this assessment, the bedtime discrepancy scores reflected the degree to which participants procrastinated going to sleep, which was our outcome variable. Conceptually informed by the self-concordance model, the second aim is to investigate the motivational aspects of bedtime procrastination in everyday life, using a longitudinal approach. We employed a week-long daily diary study in which we assessed goal motivation, goal-regulatory variables, psychological needs, and bedtime procrastination. We tested several specific hypotheses related to three overarching research questions:

Research Question 1: What is the nature of the associations between goal motives and bedtime procrastination?

a. H1a: Autonomous goal motives will be negatively associated with the bedtime discrepancy score.
b. H1b: Controlled goal motives will be positively associated with the bedtime discrepancy score.

Research Question 2: How are daily fluctuations in goal-regulatory variables associated with bedtime procrastination?

a. H2a: Daily effort will be negatively associated with the bedtime discrepancy score.
b. H2b: Daily commitment will be negatively associated with the bedtime discrepancy score.

Research Question 3: How are psychological need satisfaction and psychological need frustration related to bedtime procrastination?

a. H3a: Daily psychological need satisfaction will be negatively associated with the bedtime discrepancy score.
b. H3b: Daily psychological need frustration will be positively associated with the bedtime discrepancy score.

Methods

Participants and sample size justifications

Based on statistical simulations (Arend & Schäfer, 2019) and expert guidelines (Gabriel et al., 2019), we aim to recruit 250 participants for this study. Arend and Schäfer (2019) provided the minimum detectable effect sizes for varying parameters, including intraclass correlation coefficient, random slope variance, and level 1 and level 2 sample sizes. The simulation results showed that effect sizes of .10 for level 1 and .23 for level 2 are detected with 80% power when there are 200 participants and seven days of diary data. Informed by a review of 107 experience sampling method studies, Gabriel et al. (2019) recommended at least 83 participants for the level 2 sample size and at least 835 observations for the level 1 sample size. Based on these recommendations, we consider 250 participants providing 1750 daily responses (1400 with a modest 20% attrition rate) as adequate to observe the smallest effect size of potential interest. We included participants aged over 18 years and from the general public within the UK. We chose to recruit from this population because bedtime procrastination is highly prevalent in the general public (Kroese et al., 2016) and the proposed new measure of bedtime procrastination is easily applicable in this population. We excluded individuals who reported a sleep condition that affects their sleep (e.g. insomnia), being employed in shift work, taking medication that affects sleep (e.g. beta-blockers), or having someone that needs to be looked after overnight for care purposes (e.g. children < 3 years old, elderly). Our university's Human Research Ethics Committee approved this study prior to data collection (Approval number: HRE2023-0081).

Measures

Between-person

Demographics. We obtained information on participants' age, gender, marital status, education level, employment status, housing situation (e.g. living alone, living with a partner), number of people and children (above three years old) living at home with them, and whether they are working within traditional working hours (i.e. 9–5).

Goal motives for going to sleep on time. We assessed participants' goal motives for going to sleep on time with the 20-item Comprehensive Relative Autonomy Index (CRAI; Sheldon et al., 2017). The CRAI is based on an item- and scale-level

analysis of existing relative autonomy index measures and can be applied to behaviours within any domain of life. The CRAI is comprised of six subscales that correspond to the six regulation types outlined in self-determination theory. Intrinsic regulation reflects the extent to which participants are motivated to go to sleep on time because they take enjoyment from doing so (e.g. 'because it is a pleasure to go to sleep on time'). Identified regulation reflects motivation to go to sleep on time because participants value pursuing such a goal (e.g. 'because I strongly value going to sleep on time'). Introjected regulation refers to the extent to which participants are motivated to go to sleep on time because they want to feel good about themselves (approach: e.g. 'because I want to feel proud of myself') or avoid shame or guilty (avoidance: e.g. 'because I would feel guilty if I didn't go to sleep on time'). External regulation refers to the reasons associated with external pressures (e.g. 'because I don't have any choice but to go to sleep on time'). We excluded the amotivation subscale because it reflects the state of acting without any intention (Ryan & Deci, 2000), which is incompatible with goal pursuit. Each of these regulation types is assessed with four items, for which participants rate their agreement with each statement using a 1 (*does not correspond at all*) to 7 (*corresponds completely*) scale. We averaged intrinsic, identified, and positive introjected scores to compute an autonomous goal motivation score, and averaged negative introjected and external scores to compute a controlled goal motives score. Sheldon et al. (2017) offered evidence for the reliability and validity of the CRAI across different samples (i.e. American and Russian) and behavioural domains (i.e. going to class, studying a major, and taking responsibility).

Sleep functioning. Participants self-reported their sleep functioning over the past week *via* three items utilised in recent research (Riddell et al., 2023). Two items targeted the average hours of sleep (i.e. sleep quantity) which are 'Over the past week, on average, how many hours of sleep per 24-h cycle have you slept?' and 'How many hours of sleep per 24-h cycle do you need to feel rested and recovered the following day?' Participants provided their responses using a 0 to 24 scale. We computed the baseline sleep quantity variable by taking the mean of the responses to these two items. Participants reported their perceived level of sleep quality using a single item (i.e. 'Over the past week, on average, how would you rate the quality of your sleep per 24-h cycle?'). Single-item sleep measures were found comparable to lengthier sleep questionnaires in terms of criterion and construct validity. For example, a single-item sleep quality scale showed good psychometric properties when compared against Pittsburgh Sleep Quality Index and the Morning Questionnaire-Insomnia scale (Snyder et al., 2018). Participants provided their responses using a 0 (*completely inadequate*) to 100 (*outstanding*) scale.

Chronotype. We assessed the chronotype of the participants with the Composite Scale of Morningness (Smith et al., 1989). Example items are 'During the first half hour after having awakened in the morning, how tired do you feel?' and 'At what time in the evening do you feel tired and, as a result, in need of sleep?'. The 13

scale items are answered on a 4- or 5-point response options. We computed a total score of morningness, which can range from 13 (extreme eveningness) to 55 (extreme morningness).

Bedtime procrastination. We included the 9-item bedtime procrastination scale developed by Kroese et al. (2014) to check the association between this scale scores and bedtime average discrepancy scores. Participants provided their responses using a 1 (*never*) to 5 (*always*) scale. Example items are 'I go to bed later than I had intended' and 'I want to go to bed on time but I just don't' .

Within-person

Daily goal and sleep descriptives. Each evening between 3 pm and 8 pm, participants formed a daily sleep goal of going to sleep at night by answering the question 'What time do you plan to be in bed with the goal to fall asleep, that is, physically lying down in your bed with lights out?' and set their sleeping goal by filling in the prompt 'I plan to be in bed with the aim to fall asleep by _____ pm/am' Subsequently, participants indicated (yes/no) whether they expected to be physically or psychologically deprived the next day if they went to sleep other than what is documented in their planned goal.

Each morning, participants reported what time they lied in bed and tried to sleep the previous night and what time they roughly woke up that morning. We created the bedtime discrepancy score by calculating the time between the intended time for lying in bed and trying to sleep and the actual time for going to sleep. Further, we calculated the time between participants lied in bed to sleep and woke up to derive the sleep quantity variable. We assessed participants' sleep quality for the previous night ('How would you rate the quality of your sleep last night?') using a 0% (*terrible*) to 100% (*ideal*) scale and how many times during the night they woke up for at least 5 min.

If participants went to sleep later than they planned to do so, we probed the reason for the delay. Subsequently, we asked participants to report their subjective evaluations of the validity of the reason for bedtime delay (i.e. 'Do you think the reason you provided was a valid reason to delay your bedtime? Valid reason refers to situations where (a) bedtime delay was necessary and unavoidable, and you had no reasonable alternatives other than delaying your bedtime'). Two members of the research team, blinded to participants' interpretation of the validity of their reason, assessed the reasons for bedtime delay separately. These members were informed by the deliberate procrastination, mindless procrastination, and strategic delay categories put forward in previous research (Nauts et al., 2019), yet they did not code reasons into these groups. Instead, they classified a reason as valid when bedtime delay is necessary and unavoidable, and participants had no reasonable alternatives other than delaying their bedtime. We reported the inter-rater reliability (Cohen's Kappa) and resolved disagreements through discussion with a third member of our team. We used participants' subjective evaluations in conjunction with our assessments. At the end of classifying each reason as valid or invalid, we compared the outcomes of our assessments with participants' subjective evaluations. We reported the percentage of same conclusions (i.e. valid and invalid) between researchers and participant

perceptions (using Cohen's Kappa). We prioritised data where there is 100% agreement between participant- and researcher-coded 'invalid' reasons for going to bed to make inferences regarding the study hypotheses. We used the bedtime discrepancy scores as the outcome variable for the remaining sample. By doing so, we aimed to focus on cases of procrastination that have congruence between definition and operationalisation.

Daily adaptive goal-regulatory variables. Participants reported their goal commitment ('How committed are you to getting to sleep on time tonight?') and goal effort ('How much effort will you exert into your goal of going to sleep on time?') towards their sleep goal, each with one item, using a 1 (*not at all*) to 7 (*very much so*) scale. We assessed adaptive goal-regulatory variables in the evening survey package.

Daily psychological need satisfaction and frustration. We used the shortened version of the BPNSFS to assess daily psychological need satisfaction and frustration. This 12-item version assesses each psychological need with four items using a 1 (*not true at all*) to 5 (*completely true*) scale; two items for satisfaction and two items for frustration of needs. We averaged the six items on need satisfying experiences and the six items on need frustrating experiences to create composite scores of daily need satisfaction and daily need frustration, respectively. Previous research showed that the shortened version of the BPNSFS is internally consistent and has a two-factor solution (Mabbe et al., 2018; van der Kaap-Deeder et al., 2017). We assessed daily psychological need satisfaction and frustration in the evening survey package.

Daily affect. We used the short form of the positive and negative affect schedule (PANAS-SF; Thompson, 2007) to assess participants' daily affect levels. The PANAS scale consists of 10 items (five for positive affectual states, five for negative affectual states) and participants rated how much they experienced each type of affect that day on a 1 (*very slightly or not at all*) to 5 (*extremely*) scale. We averaged the scores on positive affectual states (e.g. inspired, active) and negative affectual states (e.g. nervous, alert) to create the composite scores of positive affect and negative affect, respectively. We provided the PANAS scale in the evening survey package.

Procedure

We employed a daily diary methodology in this study. We ran the study online on the Qualtrics platform. We recruited eligible participants *via* the online recruitment platform Prolific. Based on our previous experiences with Prolific, we expected to recruit participants within two days. To reduce the potential bias from recruiting mainly a certain group of participants (e.g. early-risers), we created five separate baseline surveys. These surveys were open for two hours consecutively between 10 am and 8 pm, with only 50 participants being able to complete surveys within each 2-h block. Participants completed the consent form, demographics questionnaire, and

baseline assessments of goal motives for going to sleep on time and sleep functioning on Sunday. Over the next seven days, participants received a morning survey at 5 am and an evening survey at 3 pm. The morning survey was designed to capture information on participants' sleep cycle on the previous night and the reason for bedtime delay (if it is delayed). Participants were able to complete the morning survey anytime between 5 am and 12 pm. The evening survey included the daily goal, goal-related items, psychological need satisfaction and frustration, affect measures. Participants were able to complete the evening survey anytime between 3 pm to 8 pm. At the end of the week, we debriefed participants about the purpose of the study and thanked them for their participation. Please see Figure 1 for the flow of the study.

Statistical analyses

We planned to use mixed-effects models with full maximum likelihood estimation using the 'lme4' package (Bates et al., 2015) within R (R Core Team, 2021). Daily diaries (within-person, level 1) were nested within participants (between-person, level 2). Before running the analysis, we grand mean centred the level 2 variables, and group mean centred the level 1 variables (Nezlek, 2011). The level 1 variables were daily effort, daily commitment, psychological need satisfaction and frustration. The level 2 variables were autonomous and controlled goal motives. The primary outcome variable was the bedtime discrepancy scores.

The analysis protocol consisted of three steps. In Step 1, we specified a null model with random intercepts to calculate the intraclass correlation coefficient, which indicated the distribution of variances across both levels. In Step 2, we entered the effect of the day of the week (1 = weekend, 0 = weekday) and daily affect, as these variables

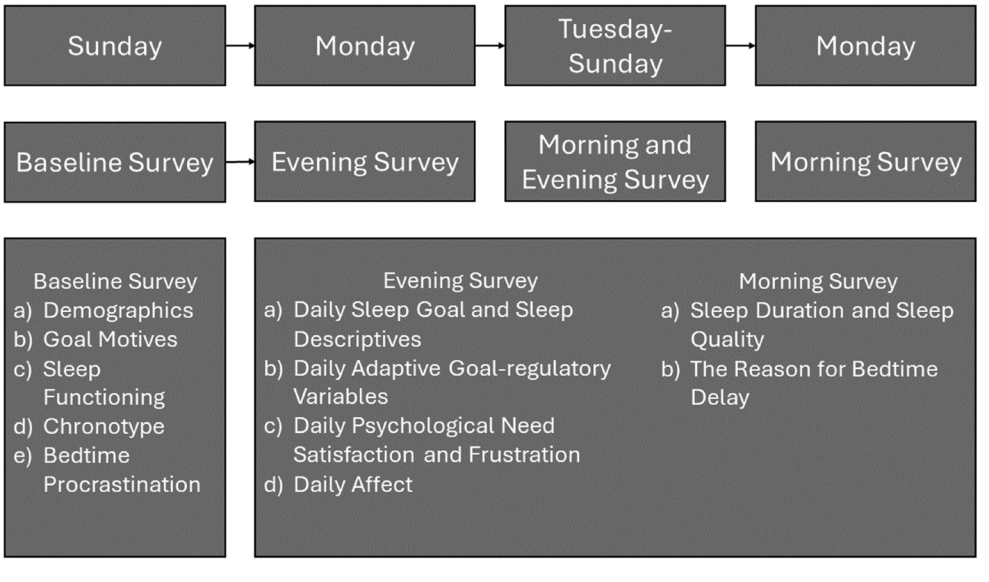

Figure 1. Visual depiction of study procedures.

were found to be associated with bedtime procrastination in previous research (Lee & Sibley, 2019; Valshtein et al., 2020). We also controlled for the effect of age, gender, chronotype, and baseline levels of sleep quantity and quality. In Step 3, we entered level 1 and level 2 predictors to check their associations with the outcome variable. We compared the model fit after adding new predictors to the model with the deviance likelihood ratio tests. We selected the alpha level of .05 for the analysis.

Finally, we conducted a series of analyses. We conducted a sensitivity analysis where we examined participant-coded or researcher-coded reasons only, with the view to see if the inferences regarding the study hypotheses changed based on the magnitude and sign of effects. We also conducted a couple of exploratory analyses. In the first exploratory analysis, each of the five goal motives (e.g. intrinsic, introjected) were entered as level 2 predictors, instead of autonomous and controlled motives. Second, we tested mediation effects of daily effort and daily commitment in the relation between autonomous goal motives and the bedtime discrepancy score. We planned to use the 'lavaan' (Rosseel, 2012) package within R to conduct a multilevel structural equation modelling with autonomous goal motives as a level 2 predictor and daily effort and daily commitment as a level 1 mediator variables. We interpreted our findings based on the compatibility between the data and the hypotheses (Greenland et al., 2022; Mansournia et al., 2022).

Timeline for completion of the study and data availability

We aimed to complete the study in three to four months after the initial submission (stage 1 of registered report) is accepted. We expected data collection to take place no more than two weeks, as we collected the data on Prolific. During the remaining time, we planned to conduct the analyses as outlined and write up the results and discussion sections. Moreover, we made the data of this study openly available on OSF (https://osf.io/rmzbc/).

Results

The data files and analysis codes can be found in the OSF page (https://osf.io/rmzbc/). We screened 502 participants in an initial survey, with 304 (61%) considered eligible for participation in the study. Additionally, we invited participants from another study (Sezer, Ntoumanis et al., 2024) that had the same set of eligibility criteria but who did not participate in the study ($n = 290$). From these 594 invitations, 343 (58%) participants filled out the baseline survey. We removed seven participants because they failed the attention check at the end of the survey by responding they would complete seven daily diary surveys in the next seven days instead of 14, bringing the final sample size to 336. The average age of participants was 43.11 years ($SD = 11.41$). The sample consisted of participants who were predominantly female (56%), either married or in a domestic partnership (64%), tertiary educated (51% bachelor's degree), employed full-time (85%), and worked traditional hours (9 am to 5 pm; 96%). Regarding their housing situation, most participants reported they lived with their partner/family (80%), where there were between 2 and 3 people in the household ($M = 3.03$, $SD = 1.08$) and typically included 1 child ($M = 0.89$, $SD = 1.16$).

Baseline sleep quantity average of participants was between 5.5 and 9 h of sleep ($M = 7.11$, $SD = 0.80$), with a medium level sleep quality ($M = 56.74$, $SD = 19.61$). During the study period, participants reported waking during the night one time on average ($M = 1.39$, $SD = 1.50$).

We were able to compute bedtime discrepancy scores for 2074 (88%) out of 2352 daily surveys. For the remaining 278 instances, participants did not complete either a morning survey, an evening survey or both for a given day. Participants provided 356 reasons for their instances of bedtime delays across these 2074 cases. We coded 105 reasons as valid reasons for delaying bedtime. Examples of valid reasons included 'cat went missing', 'family gathering', and 'child woke up'. Examples of invalid reasons included 'it is my day off work today', 'husband wanted to finish watching a TV programme', and 'computer games'. The Cohen's Kappa between the two raters was 89% (see Supplementary Material). The total number of cases that participants either did not expect to be physically or psychologically deprived the next day or had a valid reason to delay their bedtime (or a combination of both) was 1033. Thus, we excluded these occurrences from our primary analysis. In the remaining 1041 cases, participants expected to being deprived the next day and had no valid reason to delay their bedtime, thus fitting our definition. For our hypothesis testing, we ran the analysis with this subsample. In 561 of these cases, participants went to bed as intended and 480 cases involved bedtime delay. We calculated average bedtime discrepancy scores by participants and day of the week. Across participants, the average bedtime discrepancy score for the entire week was 20.73 min ($SD = 26.06$), with daily estimates ranging from 17.82 min ($SD = 31.55$) to 24.99 min ($SD = 42.51$; see Table 1). We present the within- and between-person correlations among the variables in Tables 2 and 3. The results were compatible with our expectations, such that there was a negative association between autonomous goal motives and bedtime procrastination scale scores. The association between controlled

Table 1. Means and standard deviations of bedtime discrepancy scores by day of the week.

Day of the week	Mean (min)	SD	# of BP cases
Monday	21.30	28.16	179
Tuesday	21.44	36.42	170
Wednesday	22.41	42.37	186
Thursday	24.46	70.02	158
Friday	24.99	42.51	92
Saturday	21.51	37.82	91
Sunday	17.82	31.55	165

Note. BP = Bedtime procrastination, SD = Standard deviation, min = Minutes.

Table 2. Within-person bivariate correlations.

Level 1 variables	BP	Goal commitment	Goal effort	PNS	PNF	Daily sleep quantity
Bedtime Procrastination	1					
Goal Commitment	−.05	1				
Goal Effort	−.05	.65**	1			
PNS	.00	.00	−.01	1		
PNF	.02	.00	−.01	−.35**	1	
Daily Sleep Quantity	−.44**	.08	.09	−.03	−.01	1
Daily Sleep Quality	−.16*	.06	.07	−.02	.00	.31**

Note. *$p < .01$, **$p < .001$, BP = Bedtime procrastination (discrepancy scores), PNS = Psychological need satisfaction, PNF = Psychological need frustration.

Table 3. Between-person bivariate correlations.

	AGM	CGM	Chronotype	BPS	BP	Goal commitment	Goal effort	PNS	PNF	B. sleep quant.	B. sleep qual.	Ave. sleep quant.
AGM	1											
CGM	.51***	1										
Chronotype	.19**	−.08	1									
BPS	−.25***	−.02	−.49***	1								
BP	−.10	−.01	−.30	.58***	1							
Goal Commitment	.38***	.01	.25***	−.40***	−.34*	1						
Goal Effort	.30***	.06	.14	−.23**	−.23	.88***	1					
PNS	.21**	−.08	.23***	−.25***	−.30**	.35***	.24**	1				
PNF	−.02	.30***	−.22**	.38***	.22	−.12	−.04	−.48***	1			
Baseline Sleep Quantity	.12*	.08	−.14*	−.16**	.07	.10	.00	.09	−.15	1		
Baseline Sleep Quality	.08	.08	.19**	−.23**	−.03	.06	−0.06	.22**	−.33***	.26***	1	
Average Sleep Quantity	.12	.04	.02	−.26***	−.19	.08	.01	.14	−.12	.50***	.08	1
Average Sleep Quality	.16*	.09	.11	−.22**	−.18	.23**	.07	.54***	−.37***	.15*	.60***	.08

*$p < .05$.
**$p < .01$.
***$p < .001$, AGM = Autonomous goal motives, CGM = Controlled goal motives, BPS = Bedtime procrastination scale, BP = Bedtime procrastination (discrepancy scores), PNS = Psychological need satisfaction, PNF = Psychological need frustration B. Sleep Quant. = Baseline sleep quantity, B. Sleep Qual. = Baseline sleep quality, Ave. Sleep Quant. = Average sleep quantity.

goal motives with bedtime procrastination scale scores included both positively and negatively signed effects. There was a negative association between chronotype and bedtime procrastination scale scores, suggesting participants with morning chronotype scored lower on the bedtime procrastination scale. The between-person correlation between bedtime procrastination scale scores and bedtime discrepancy scores after excluding within-person variance was .58 (95% CI = 0.43, 0.73).

Hypothesis testing analyses

We deviated from our preregistered statistical analysis plan by using the Mplus software (Muthén & Muthén, 2017) instead of the 'lavaan' package (Rosseel, 2012) within R (R Core Team, 2021), as Mplus allows a smoother execution of the analyses compared to using multiple packages in R. Apart from this deviation, there was no difference in the analysis plan.

We started the analysis with Step 1 in which we specified a null model with random intercepts to calculate the intraclass correlation coefficient (ICC) across levels. The results indicated that 14.5% of the variance in bedtime procrastination was at the within-person level. In Step 2, we entered the covariate variables into the model (N_{obs} = 1,014). The goodness-of-fit indices for the model were as follows: $\chi^2(14) = 101.09$, $p < .001$, CFI = 1.00, RMSEA = .000, $SRMR_{within}$ = .000, $SRMR_{between}$ = .002, Akaike Information Criteria (AIC) = 10,294.88, Bayesian Information Criteria (BIC) = 10,378.55. At the within-person level, there was a negative association between daily sleep quantity and bedtime discrepancy scores. The remaining within-person level variables were not meaningfully associated with bedtime discrepancy scores. At the between-person level, participant age, chronotype, average sleep quantity and sleep quality across the week were negatively associated with bedtime discrepancy scores. The remaining between-person level variables evidenced associations with bedtime discrepancy scores that were low in compatibility with only a positive or negative sign (see Table 4).

In Step 3, within-person (goal effort, goal commitment, psychological need satisfaction, and psychological need frustration) and between-person (autonomous goal motives and controlled goal motives) level predictors were added to the model (N_{obs} = 1,014). We also entered random intercepts and random slopes for the within-person level predictors. The goodness-of-fit indices for the model were unavailable because the variances varied across subjects in random slope models. The AIC and BIC values were 10,314.63 and 10,467.20, respectively. Participant age, chronotype, and average sleep quantity were still negatively associated with bedtime discrepancy scores; average sleep quality was no longer significant. None of the predictors added in Step 3 were associated with bedtime discrepancy scores in ways that met our criteria for high compatibility with a positive or negative sign only (see Table 4 for coefficients). The deviance likelihood ratio test revealed that there was no improvement in the model fit after adding the predictor variables in Step 3, $\chi^2(14) = 8.25$, $p = .876$.

Sensitivity analyses

Full results of our sensitivity analyses are presented in Table 4. We examined participant-coded reasons for validity of bedtime delays to check if there was any

Table 4. Comparison of multilevel model results of the main analysis and sensitivity analyses.

	Main analysis				Sensitivity analyses			
	Step 2		Step 3		Participant-coded Reasons		Outliers Excluded	
Variables	B (95% CI)	*p*	B	*p*	B	*p*	B	*p*
Within-person	N_{obs} = 1,014		N_{obs} = 1,014		N_{obs} = 954		N_{obs} = 936	
Sleep Quantity	**−0.30 (−0.39, −0.21)**	**.000**	**−0.30 (−0.40, −0.19)**	**.000**	**−0.28 (−0.40, −0.17)**	**.000**	**−0.24 (−0.31, −0.17)**	**.000**
Sleep Quality	−0.07 (−0.27, 0.12)	.453	−0.07 (−0.25, 0.10)	.419	−0.07 (−0.24, 0.09)	.387	−0.10 (−0.24, 0.04)	.179
Weekday	0.48 (−4.04, 4.99)	.837	0.60 (−3.89, 5.10)	.792	0.47 (−4.12, 5.06)	.841	0.49 (−4.66, 3.68)	.817
PA	−0.60 (−4.42, 3.22)	.759	−0.49 (−5.09, 4.10)	.833	−1.97 (−8.56, 4.62)	.558	−0.25 (−4.81, 4.30)	.914
NA	−1.23 (−7.91, 5.45)	.718	−1.32 (−8.09, 5.45)	.702	−2.25 (−10.19, 5.70)	.579	−5.41 (−13.04, 2.22)	.165
Goal Commitment			−0.22 (−3.20, 2.77)	.887	−0.01 (−4.39, 4.38)	.998	−1.19 (−4.23, 1.85)	.444
Goal Effort			−0.29 (−4.89, 4.32)	.904	−0.06 (−3.23, 3.12)	.971	−1.00 (−4.25, 2.26)	.548
PNS			−0.10 (−5.99, 5.78)	.973	−0.01 (−9.69, 9.66)	.998	−0.14 (−5.52, 5.25)	.961
PNF			0.24 (−6.03, 6.50)	.941	0.03 (−8.52, 8.57)	.995	0.21 (−4.89, 5.31)	.935
Between-person	*n* = 288		*n* = 288		*n* = 285		*n* = 267	
Age	**−0.30 (−0.55, −0.05)**	**.017**	**−0.28 (−0.55, −0.01)**	**.042**	−0.26 (−0.55, 0.02)	.071	**−0.31 (−0.54, −0.07)**	**.011**
Gender	−1.61 (−7.22, 3.99)	.573	−1.43 (−7.18, 4.32)	.626	−1.12 (−7.10, 4.87)	.715	−4.07 (−8.48, 0.33)	.070
Chronotype	**−10.64 (−16.14, −5.14)**	**.000**	**−10.47 (−16.18, −4.76)**	**.000**	**−10.94 (−17.21, −4.68)**	**.001**	**−8.84 (−13.67, −4.01)**	**.000**
B. Sleep Quant.	3.69 (−0.81, 8.19)	.108	4.53 (−0.22, 9.27)	.062	4.62 (−0.33, 9.58)	.068	0.62 (−2.16, 3.39)	.663
B. Sleep Qual.	0.10 (−0.07, 0.26)	.245	0.10 (−0.08, 0.28)	.279	0.12 (−0.07, 0.31)	.202	0.00 (−0.14, 0.14)	.981
Ave. Sleep Quant.	**−0.15 (−0.24, −0.06)**	**.001**	**−0.15 (−0.24, −0.06)**	**.002**	**−0.15 (−0.25, −0.05)**	**.004**	**−0.09 (−0.14, −0.03)**	**.002**
Ave. Sleep Qual.	**−0.21 (−0.39, −0.03)**	**.025**	−0.16 (−0.35, 0.03)	.098	−0.19 (−0.40, 0.01)	.064	−0.05 (−0.20, 0.10)	.494
Ave. PA	0.57 (−3.07, 4.21)	.758	4.26 (−0.78, 9.29)	.097	3.79 (−0.90, 8.47)	.113	2.49 (−2.09, 7.06)	.287
Ave. NA	1.85 (−4.05, 7.74)	.539	0.90 (−6.39, 8.20)	.808	1.34 (−6.53, 9.22)	.738	3.46 (−11.08, 4.16)	.374
AGM			1.93 (−1.26, 5.12)	.235	2.10 (−1.42, 5.61)	.243	−0.82 (−3.22, 1.59)	.506
CGM			−2.67 (−6.26, 0.92)	.145	−2.92 (−6.76, 0.92)	.136	0.08 (−2.74, 2.89)	.957
Ave. Goal Effort			1.81 (−1.89, 5.51)	.338	1.13 (−2.30, 4.56)	.518	0.29 (−2.96, 3.53)	.863
Ave. Goal Commitment			−5.32 (−10.82, 0.18)	.058	−4.49 (−9.78, 0.78)	.095	−1.83 (−5.95, 2.30)	.386
Ave. PNS			−4.57 (−9.99, 0.86)	.099	−4.46 (−10.03, 1.12)	.117	−4.04 (−8.94, 0.85)	.105
Ave. PNF			1.91 (−4.79, 8.61)	.577	3.12 (−3.68, 9.91)	.369	3.07 (−3.84, 9.98)	.384

Note. B. Sleep Quant. = Baseline sleep quantity, B. Sleep Qual. = Baseline sleep quality, PA = Positive affect, NA = Negative affect, Ave. Sleep Quant. = Average sleep quantity, Ave. Sleep Qual. = Average sleep quality, AGM = Autonomous goal motives, CGM = Controlled goal motives, PNS = Psychological need satisfaction, PNF = Psychological need frustration, CI = Confidence Intervals. Bold cells indicate estimates with confidence intervals not containing zero.

difference in the results compared with researcher-assessed reasons. The number of observations at the within-person level dropped from 1014 to 954, suggesting that participants evaluated their reasons for bedtime delay as valid more frequently than researchers. The criteria that we and participants used to assess the validity of reasons seemed different, as the Cohen's Kappa was 37% for cases that were considered valid by both researchers and participants. There was no difference in the results compared to the main analysis, except that age was no longer significantly associated with bedtime discrepancy scores.

Although absent from our pre-registered analysis plan, we also conducted a sensitivity analysis where we checked outlier cases in the dataset. We first standardised all variables included in the final model (e.g. covariates, predictors). There were 26 participants who had an absolute z-score greater than three for at least one or more variables. We removed these outlier cases from the dataset and re-ran Step 3 of the main analysis. There was no difference in the results compared to the main analysis.

Exploratory analyses

Full results of our exploratory analyses are provided on the OSF page (https://osf.io/rmzbc/). First, we replaced autonomous and controlled goal motives with each of the five goal motives subscale scores (i.e. intrinsic, identified, positive introjection, negative introjection, and external motives) as level 2 predictors. There was no change in the results at the within-person level. The negative association between daily sleep quantity and bedtime discrepancy scores evidenced high compatibility ($B = -0.30$, %95 $CI = [-0.40, -0.19]$, $p < .001$). At the between-person level, chronotype ($B = -10.44$, %95 $CI = [-16.38, -4.51]$, $p = .001$), average sleep quantity ($B = -0.14$, %95 $CI = [-0.23, -0.05]$, $p = .002$), and identified goal motives ($B = -3.64$, %95 $CI = [-6.34, -0.95]$, $p = .008$) were associated with lower bedtime discrepancy scores. Positive introjection motives ($B = 2.71$, %95 $CI = [0.06, 5.35]$, $p = .045$) were associated with higher bedtime discrepancy scores. Second, we tested the mediation effects of daily effort and daily commitment in the relation between autonomous goal motives and the bedtime discrepancy score. None of the indirect effects nor the total indirect effect were associated with bedtime discrepancy scores in ways that met our threshold for high compatibility with a positive or negative sign only. Finally, we ran an exploratory analysis which included the bedtime procrastination scale as a covariate at the between-person level. Chronotype ($B = -7.04$, %95 $CI = [-12.34, -1.75]$, $p = .009$) and average sleep quantity across the week ($B = -0.13$, %95 $CI = [-0.22, -0.04]$, $p = .003$) were negatively associated with bedtime discrepancy scores; bedtime procrastination scale scores ($B = 8.15$, %95 $CI = [4.48, 11.81]$, $p < .001$) were positively associated with bedtime discrepancy scores.

Discussion

Bedtime procrastination is detrimental to sleep health by way of disrupting regular sleep patterns and leading to less sleep overall (Hill et al., 2022). We addressed methodological and conceptual gaps in the bedtime procrastination literature by proposing an updated definition of bedtime procrastination and operationalising it in line with

this concept definition. Our updated definition incorporated the non-volitional aspect of bedtime procrastination (e.g. losing track of time) and explicitly detailed the phrase 'worse off' in the original definition as 'physically or psychologically deprived'. The findings provided support for the new operationalisation of bedtime procrastination, as indicated by the consistent associations with sleep outcomes and chronotype. The inverse association between bedtime discrepancy scores and sleep quantity at both within-person and between-person levels were consistent with expectations. Also consistent with past research, we found extreme morningness (chronotype) was inversely associated with bedtime procrastination. Importantly, this new operationalisation of bedtime procrastination based on its three necessary and sufficient criteria was feasible by incorporating only a couple of questions in the daily surveys. The second aim was to examine the motivational factors related to why people go to sleep later than when they intend to sleep. The results evidenced low compatibility with our hypotheses, whereby associations between bedtime procrastination and autonomous or controlled forms of goal motives, daily goal-regulatory variables (i.e. effort, commitment), and psychological needs included both positively and negatively signed effects.

A primary contribution of our work is an updated definition of bedtime procrastination and operationalisation of the concept in a way that maximises congruence with this definition. Regarding the definition of bedtime procrastination, we proposed an update to previous formalisations, in which it is explicitly acknowledged that bedtime procrastination is a volitional decision and, hence, excludes unintentional cases of bedtime delays. In addition to deliberately deciding to delay bedtime, people can also lose track of time by engaging in immersive activities (e.g. scrolling on social media) and only realise when they disengage that they passed their bedtime goal (Nauts et al., 2019). Numerous participants self-reported such immersive activities (e.g. watching TV/movie, talking/scrolling on the phone) as reasons for their bedtime delay. This trend speaks to the importance of addressing non-volitional cases of bedtime delay in the definition. Furthermore, we revised the wording from 'worse off' in the original definition to 'physically or psychologically deprived', as the original phrasing was unclear about the specific ways in which people might be negatively impacted by bedtime procrastination. From an operational standpoint, delayed sleep, expectations of being physically or psychologically deprived the next day, and not having a valid reason to delay sleep represent the necessary and sufficient conditions to evaluate bedtime delays in ways that are congruent with the concept definition of bedtime procrastination (Kroese et al., 2016; Kroese et al., 2014).

The operationalisation of bedtime procrastination in previous research often excludes one or more of these key elements, which render findings inconclusive or incongruent with the conceptual definition. For example, in their meta-analysis, Hill et al. (2022) reported that 95% of the included studies used the bedtime procrastination scale to measure bedtime procrastination. The bedtime procrastination scale is more fit to assess trait-like features of bedtime procrastination that are relatively stable and consistent elements. However, it is inadequate in addressing two of the three criteria for bedtime procrastination (i.e. expectations, valid reason). Thus, our updated operationalisation of and findings regarding bedtime procrastination potentially motivate a reconsideration of existing knowledge. For example, our findings

indicated an average bedtime discrepancy score of around 20 min and within-person variation of approximately 14.5%, which differ substantially from previous research (75%; Kühnel et al., 2018). The large within-person variation found by Kühnel et al. (2018) could be due to utilising a slightly adapted version of the bedtime procrastination scale for daily diaries, which disregards the two criteria of expectations of being deprived the next day and having a valid reason to delay sleep. In our sample, we discarded 50% of the bedtime delay cases because they did not fit with the criteria. Including those cases that should be excluded otherwise might have inflated the within-person variation in previous research. We showed that it is feasible to measure bedtime procrastination in line with its definition by probing participants to self-report whether they expect to be deprived the next day and if they had a reason for their bedtime delay. In so doing, we showcased for the first time a robust operationalisation of bedtime procrastination that aligns within the concept definition.

An independent, yet related, contribution is the characterisation of bedtime procrastination as it manifests across a week in ways that are sensitive to person-context interactions. Our findings confirmed both trait and state elements to bedtime procrastination, with 14.5% of the variance associated with intra-individual dynamics. Consistent with past research on bedtime procrastination (Hill et al., 2022; Kühnel et al., 2018), we observed high compatibility associations between our operationalisation of bedtime procrastination with relevant sleep outcomes (e.g. sleep quantity) and individual qualities (e.g. chronotype). We also observed a strong correlation between bedtime discrepancy scores and self-reported bedtime procrastination *via* the bedtime procrastination scale questionnaire. In sum, our work offers an updated definition and operationalisation of bedtime procrastination, which aligns with its conceptual drivers, clarifies inconsistencies in past research, and reveals both trait and state dynamics of this behaviour across the week.

Contrary to expectations, we found absence of evidence for any of our pre-registered hypotheses regarding the associations between bedtime procrastination and goal motives, daily fluctuations in goal-regulatory variables, or psychological need satisfaction and frustration. There are likely conceptual and methodological reasons for these low compatibility findings. Regarding our sampling of the population, sample characteristics suggest that participants were middle-aged in their 40s whose lives can be assumed to be reasonably structured. Professionally, 96% of participants worked traditional hours (9 am to 5 pm). Personally, 80% of the participants lived with their partner/family. The living situation of participants is an essential consideration because many of the reasons we coded as valid for bedtime delay involved interpersonal dynamics with family members, loved ones, or romantic partners (e.g. 'family gathering', 'had to pick up my partner from the train station who was late back which delayed my evening'). Relatedly, participant age was inversely associated with bedtime discrepancy scores across all models, suggesting that older participants procrastinated their bedtime less. The implication of this robust finding, and the demographics of our sample, may be that older individuals tend to have more established sleep routines which help with going to sleep on time (Larsen & Jordan, 2022). Sampling people for whom bedtime procrastination is a known issue (e.g. people with heavy social media use; Chung et al., 2020), rather than general population, should be an important future direction upon which to evaluate the inferential validity of future work.

Autonomous and controlled goal motives are well established correlates and determinants of key health-related behaviours and outcomes (Sezer et al., 2024). We extend this extensive body of work and previous efforts that have targeted motivational regulations of bedtime procrastination (Kadzikowska-Wrzosek, 2020) to consider the motives underlying the goals people set regarding the time they go to bed. Contrary to theory (Sheldon & Elliot, 1999) and empirical evidence (Sezer et al., 2024), our findings showed low compatibility regarding the expectations that autonomous goal motives are adaptive and controlled goal motives are maladaptive for bedtime procrastination. The associations between goal motives and bedtime procrastination observed here are similar to what we reported in another registered report of 281 middle-aged adults aged around 42 years (Sezer, Ntoumanis et al., 2024). It might be the case that the goal of sleeping on time is something participants pursue because they place value on it, but not something for which they find inherently enjoyable or interesting. This explanation is supported through our exploratory analysis with each of the five goal motives, which allowed us to investigate the nature of the associations at a nuanced level. Identified goal motives, which reflect the value participants place towards going to sleep on time, evidenced high compatibility with lowered bedtime discrepancy scores. In contrast, the association between bedtime procrastination and intrinsic goal motives, which are related to the enjoyment aspect of going to sleep on time, was compatible with diverse possibilities including positive and negative effects. Thus, our approach to amalgamate intrinsic and identified goal motives may have cancelled out the positive effects of the identified motives. These associations suggest that it was predominantly the personal valuation of the reason of going to sleep at the intended bedtime which lowered participants' bedtime procrastination levels, and not the perception that this goal was enjoyable.

We also found low compatibility for our hypotheses regarding daily fluctuations in goal effort and goal commitment with bedtime procrastination. Goal effort and goal commitment are two of the most examined goal-regulatory variables in the self-concordance literature (Sezer et al., 2024). Both have been repeatedly shown to be positively associated with autonomous goal motives and successful attainment of goals (e.g. Koestner et al., 2012; Milyavskaya et al., 2022). The inconsequential findings in this study may stem from a mismatch between participants' anticipated and exerted levels of effort and commitment. We assessed goal-regulatory variables at the same time when participants were setting their bedtime goals, which implies their effort and commitment scores reflect their perceived level of effort and commitment they are anticipating putting into that day. However, participants might have found exerting effort and commitment into their bedtime goal challenging at the end of the day for numerous reasons (e.g. temptations, conflict with other goals). An alternative explanation is that goal effort and goal commitment were very highly correlated (r = .88) at the between-level, hence they were unable to explain a sufficiently unique amount of variance of bedtime procrastination. The negative bivariate correlation at the between-level between goal commitment and bedtime procrastination evidenced high compatibility and was aligned with past research findings.

Our findings indicated low compatibility between going to sleep as intended and psychological need satisfaction or psychological need frustration. Previous research on psychological needs suggests that attainment of goals that are autonomously

pursued would be related to higher satisfaction of psychological needs. We expected to catch those boosts in need satisfaction through the daily surveys of participants who successfully attained their goals. Contrary to our expectations, the within-person association between psychological need satisfaction and bedtime discrepancy scores encompassed broad ranges of effects in sign and magnitude, suggesting that there was no pattern of findings where participants reported an increase in the satisfaction their psychological needs on days they procrastinated their bedtime less. Part of the reason for this non-significant association could be because we assessed psychological need satisfaction at broader level than specific to going to sleep on time. Vallerand (1997) postulates that measuring the SDT predictors at the same level as the outcome variable is more likely to draw accurate conclusions than measuring them at a higher level. We measured participants' general daily psychological need satisfaction and frustration, which could be affected by other stimuli in their daily lives.

As with all studies, there are several limitations that need to be considered when assessing the inferential value of our work. First, we overestimated the likely prevalence of bedtime procrastination after ruling out cases in which participants did not expect to be deprived the next day or had a valid reason for their bedtime delay. Even though we had sufficient sample size at the between-person level, we ended up with fewer cases at the within-person level than we expected. As the first study to apply an operationalisation of bedtime procrastination that satisfies all necessary and sufficient conditions, we suggest for future research to adjust sample size calculations accordingly. Relatedly, a simple 'yes or no' answer to the prompt regarding participants' expectations for being deprived may be insufficient; rather, asking each type of deprivation (i.e. physical, psychological) separately on a larger scale (e.g. 10-point) and using the middle point as the cut-off could be a better alternative.

A second limitation is that we had to exclude daily surveys from participants who completed either the morning or evening survey only. In such cases, it was impossible to calculate the bedtime discrepancy scores without one's intended bedtime or their actual waketime. Device-based assessments of sleep to maximise survey completion could alleviate such concerns. Third, our coding of reasons for bedtime delays inevitably includes subjectivity on our part. Despite this subjectivity, we coded each reason separately with two independent coders, who reached 89% interrater reliability. We also asked participants subjective evaluations of their own reasons, and observed inconsequential difference in the results. Nevertheless, it should be noted that the criteria we and participants used to assess the validity of reasons seemed to differ, as indicated by the interrater reliability between the two (37%). Although the information provided by participants to the researchers can be limited when assessing the reasons, participants might also be biased when evaluating their own reasons. Finally, sampling from the general population may have restricted our capacity for studying bedtime procrastination, as explained earlier.

In conclusion, we showed that it is feasible to assess bedtime procrastination based on its criteria. The new operationalisation can be implemented without any extra burden on the researchers or participants. The assessment, however, requires an optimisation to retain as many cases as possible while still examining each criterion adequately. Our results concerning our hypotheses were not in line with our expectations. We suggest focusing on younger participants or participants with problematic

electronic media use, where bedtime procrastination may be a more serious issue, when investigating bedtime procrastination and associated motivation-related constructs.

Note

1. Differing from the original definition (Kroese et al., 2016), we focus on the sleep-delaying aspect of bedtime procrastination, rather than delaying going to bed, as one can go to bed with the intention of sleeping but still check their social media or read a book.

Disclosure statement

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Data availability statement

The data used for the analyses in this study is available in the OSF project page (https://osf.io/rmzbc/).

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