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Too exhausted to go to bed – Implicit theories about willpower and stress affect bedtime procrastination

Short title: *Willpower theories and bedtime procrastination*

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Keywords: Self-control, bedtime procrastination, implicit theories about willpower

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Abstract

While most people are aware of the importance of sleep for their health, well-being, and performance bedtime procrastination is a pervasive phenomenon that can be conceptualized as a case of self-control failure (Kroese, De Ridder, Evers, & Adriaanse, 2014). Two daily diary studies (N_1 = 185, N_2 = 137) investigated beliefs about willpower and stress as interactive predictors of bedtime procrastination. Beliefs about willpower capture whether people think of their willpower as limited resource that gets easily exhausted (limited theory) or as something that remains regardless of previous acts of self-control (nonlimited theory). Results show that after a stressful day, people with a limited versus nonlimited theory procrastinate more on going to bed, while there is no difference in bedtime procrastination on less stressful days. Thus, ironically, limited theorists who should be more concerned with recovering their resources after a stressful day sleep less the following night.

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Introduction

It is without question that sleep serves important functions (Stickgold, 2001). Insufficient and low quality sleep has adverse consequences for people's physical health, their subjective well-being, and cognitive functioning. For instance, too short (as well as too long) sleep has been discussed as a risk factor for common chronic diseases, such as obesity, type 2 diabetes, and hypertension (e.g., Buxton & Marcelli, 2010; Gangwisch et al., 2006; Sabanayagam & Shankar, 2010). Sleep insufficiency is further associated with impaired cognitive functioning, emotional instability, as well as lower levels of optimism, positive affectivity, and purpose in life (Drummond et al., 1999; Gohar et al., 2009; Haack & Mullington, 2005; Harrison & Horne, 2000; Ram, Seirawan, Kumar, & Clark, 2010; Steptoe, O'Donnell, Marmot, & Wardle, 2008; Stickgold, 2001). Thereby, research suggests that sleep is particularly important during phases of brain maturation and sleep deprivation having particularly adverse effects on adolescents (Dahl & Lewin, 2002; Dewalda, Meijer, Oort, Kerkhof, & Bögels, 2010).

Despite the importance of sleep for physical and mental health, studies suggest that many people go to bed later than planned without external or physiological reason—a phenomenon called *bedtime procrastination* (Kroese, De Ridder, et al., 2014; Kroese, Evers, Adriaanse, & De Ridder, 2014; Nauts, Kamphorst, Sutu, Poortvliet, & Anderson, 2016). When procrastinating on their bedtime, people fail to behave in a way that would benefit their long-term goals for well-being and health. Accordingly, bedtime procrastination resembles a typical self-control problem (Kroese, Evers, et al., 2014). We investigate people's beliefs—or implicit theories—about willpower and stress as predictors of bedtime procrastination, both of which have been found to interactively affect self-control in everyday life (Job, Dweck, & Walton, 2010; Job, Walton, Bernecker, & Dweck, 2015). Thereby, the present research

contributes to knowledge about motivational factors of functional and dysfunctional sleep patterns.

The Phenomenon of Bedtime Procrastination

Studies suggest that 28% of U.S. adults report to sleep only 6 hours per night or less, while 7-8 hours is conventionally considered ideal (Krueger & Friedman, 2009; Ram, Seirawan, Kumar, & Clark, 2010; Sabanayagam & Shankar, 2010). With regard to the younger population, the picture becomes even worse. Although there is evidence that many adolescents may have sleep needs that exceed the recommended 8 to 9 hours each night, they have been shown to receive significantly less (Carskadon, 1990). For instance, a study with 3311 adolescents from nine European countries found that about 33% of adolescents sleep less than 8 hours (Garaulet et al., 2011).

Taking a self-regulation perspective on the problem of insufficient sleep, Kroese et al. (2014) introduced the concept of bedtime procrastination. They argue that people tend to procrastinate on their bedtime unnecessarily limiting their hours of sleep. In a representative sample of 2,431 Dutch adults (excluding people diagnosed with a sleeping disorder or people working nightshifts), over 50 % reported going to bed later than they would like to and, accordingly, 45 % indicated feeling tired during the day on two or more days per week (Kroese, Evers, et al., 2014). These data speak for the pervasiveness of the phenomenon and call for the investigation of its driving factors. To be able to study the consequences and precursors of the phenomenon, Kroese et al. (2014) developed a questionnaire to assess bedtime procrastination and, in a first step, tested its association with sleep outcomes. Speaking for the validity of the questionnaire bedtime procrastination was negatively associated with sleep duration and positively associated with the experience of insufficient sleep and fatigue during the day (Kroese, De Ridder, et al., 2014; Kroese, Evers, et al., 2014).

In terms of precursors of bedtime procrastination, first evidence suggests that people's self-control capacity plays a role. Like other forms of procrastination (e.g., academic procrastination) bedtime procrastination can be understood as self-control failure: While most people know about the importance of sufficient sleep, short-term motives may render their best intentions to go to bed on time. For instance, people may want to relax from the day and have some "me time" before going to bed. In line with the conceptualization as self-control problem, studies found that people low in trait self-control and those high in trait procrastination engage more in bedtime procrastination (Kroese, De Ridder, et al., 2014; Kroese, Evers, et al., 2014).

Different to other forms of procrastination, however, sleep is overall experienced as enjoyable and the reasons why people engage in bedtime procrastinate are not as clear as, for instance, when students procrastinate on their homework. Along these lines, Nauts and colleagues (2016), argue that people do not procrastinate on their sleep per se but rather on starting the evening routine (e.g., brushing teeth), which may be perceived as unpleasant. Indeed, they found that people who perceive their evening routines as more unpleasant report more bedtime procrastination (Nauts et al., 2016).

The present research extends this line of research by examining people's beliefs about willpower and stress as possible predictors for bedtime procrastination. Previous research found that these two factors interactively predict self-control failure in everyday life (Job et al., 2010; Job, Walton, et al., 2015).

Implicit Theories About Willpower and Stress

The most influential model in the self-control literature in the past two decades was the Strength Model of Self-Control (Baumeister, Bratslavsky, Muraven, & Tice, 1998). This model posits that self-control depends on a limited resource and that acts of self-control can lead to a state of "ego-depletion" which unequivocally leads to self-control failure. As

alternative explanation to the idea of a truly limited resource, Job and colleagues (2010) proposed that people differ in their implicit theories about the availability of self-control resources or in lay terms their "willpower" (Job et al., 2010): Some people believe that their willpower resembles a limited resource that gets exhausted by activities that require self-control. According to this so called *limited theory*, resisting temptations, engaging in strenuous mental tasks, or regulating emotions takes up resources that need to be restored for their willpower to function well again. Restoration of resources can be achieved, for instance, by taking a break or eating. But there are also people who think of their willpower as nonlimited capacity that functions well regardless of previous self-control efforts. People with a so called *nonlimited theory* think that their willpower may even get activated through self-control exertion.

Laboratory and field research suggests that beliefs about willpower affect people's self-control performance (Job et al., 2010; Job, Walton, et al., 2015). Experimental studies, for instance, showed that people with a limited theory (measured or induced) performed less well in a self-control task, if they had just engaged in another self-control task beforehand; in contrast, people with a nonlimited theory performed well regardless of preceding self-control efforts (Job et al., 2010; see also Miller et al., 2012). Complementing these findings, field studies showed that a limited theory is related to impaired self-regulation, particularly in times when people face high self-regulatory demands (Job et al., 2010; Job, Walton, et al., 2015). For instance, studies found that in the final, demanding phase of the term students with a limited theory procrastinate more on their classwork, eat less healthy, and regulate emotions less well than students with a nonlimited theory (Job et al., 2010; Job, Walton, et al., 2015). Along these lines, another field study tested the idea that beliefs about willpower may also predict whether stress experienced in one day may affect people's self-regulatory capacity the following day (Bernecker & Job, 2015). Against the expectation that people with a limited

theory show *less* efficient goal striving after a stressful day, it were people with a nonlimited theory who were striving *more* efficiently for their goals after stressful days (Bernecker & Job, 2015). Thus, it seems that stress experienced over the course of a day may also have positive effects on self-regulation for people who endorse a nonlimited theory.

Extending previous work on the effects of willpower theories on self-control in everyday life, the present research tested whether the beliefs people hold about their willpower also predict bedtime procrastination, as another manifestation of self-control failure in everyday life. Based on the previous findings, we expected that the effects of willpower theories are most pronounced when people faced high self-regulatory demands. More specifically, we expect that on stressful days people with a limited theory engage in more bedtime procrastination than people with a nonlimited theory.

The Present Research

We tested our hypothesis in two daily diary studies. Because insufficient sleep is particularly problematic within younger age, we recruited a college student sample (Study 1) and a sample of high school students (Study 2). Further, because later bedtimes can also be intentional rather than the result of bedtime procrastination, we assessed individuals' ideal bedtimes in both studies. The discrepancy between ideal and actual bedtime served as a measure for bedtime procrastination. Further, bedtime procrastination may not necessarily result in shorter sleep duration, when people have the opportunity to sleep long in the morning. Therefore, we also assessed the time when participants got up in the mornings and calculated their sleep duration. Last, we assessed potential third variables that may account for the effects of willpower theories, such as trait self-control (Study 1), chronotype (Study 1), and trait procrastination (Study 2). [1]

Study 1

Study 1 provided the initial test of our hypothesis, namely that people with a limited versus nonlimited theory engage more in bedtime procrastination following a stressful day. We controlled for trait self-control, because previous studies found trait self-control to be associated with willpower theories and bedtime procrastination (Bernecker, Herrmann, Brandstätter, & Job, 2017; Kroese, Evers, et al., 2014).

Method

We administered a daily diary study (10 workdays) and assessed different aspects of participants' daily sleep behavior (i.e., bedtime, get-up time, sleep quality) and levels of stress. The study was approved by the institutional review board.

Procedure and Participants

The study was advertised in lectures, via mailing lists and flyers. Upon registration for the study via email participants received a link to an initial questionnaire that yielded the information about the study procedure, the informed consent, trait measures, and ideal bedtime. Daily questionnaires were sent out at 5:00 am via email from Monday to Friday for two weeks. The first diary week was located in the middle of the term and the second at the end of the term just before the final examination period. The distribution of the two diary phases was chosen to assure sufficient within-person variance in stress.

A total of $N = 185$ (86.4% female, $M_{age} = 21.73$ years, $SD_{age} = 4.18$) participants registered for the study and filled in the initial questionnaire. Out of this initial sample $n = 173$ participants filled in at least one daily questionnaire. Response rate for the daily questionnaires was high with 89.4% (1547 out of 1730 questionnaires) with an average of 9.02 ($SD = 2.30$) questionnaire provided per participant. Participants were asked to fill in the daily survey before 11:00 am, which was the case for 90.8% of questionnaires.

Post-hoc power analyses using a simulation procedure in R with 1000 simulated

studies (Lane & Hennes, 2018), suggested that the power for detecting the cross-level interaction for our main outcome bedtime procrastination was 0.81.

Measures of Initial Questionnaire

All measures reported below were originally assessed in German. If not indicated otherwise the measures were developed for the study and can be obtained from the corresponding author upon request.

Implicit theories about willpower. As part of the initial questionnaire participants completed a shortened German version of the Willpower Theory Scale (Job et al., 2010). Four items assessed willpower theories for the domain of resisting temptations (e.g., "Resisting temptations makes you feel more vulnerable to the next temptations that come along" [limited theory], "After you have resisted temptations your capacity to face upcoming temptations is still the same", $\alpha = .70$). All items were rated on 6-point scale (1 = *strongly agree* to 6 = *strongly disagree*). Items reflecting a limited theory were reverse-scored so that higher values on the averaged scale represent greater agreement with a limited theory.

Trait self-control. Trait self-control was assessed with the German short version of the Trait Self-Control Scale (Bertrams & Dickhäuser, 2009; Tangney, Baumeister, & Boone, 2004), consisting of 10 items (e.g., "I say inappropriate things"), which were rated on a 6-point Likert-type scale (1 = *not at all* to 6 = *very much*) and averaged to one scale with high values representing high trait self-control.

Chronotype. Chronotype was assessed with one item asking "People often speak of 'morning' and 'evening types'. What type applies to you?" (1 = *morning type*, 2 = *rather morning that evening type*, 3 = *rather evening than morning type*, 4 = *evening type*).

Ideal bedtime. Ideal bedtime was assessed with one item asking participants, "What do you think, when should you go to sleep on a normal workday in order to be fit on the next day." Participants provided their ideal bedtime in a hh:mm format in an open response field.

Measures of the Daily Questionnaires

Bedtime. Daily bedtime was assessed asking participants, "When did you go to sleep yesterday"? An additional instruction clarified that participants should report the time when they actually went to sleep and not the time when they went to bed (e.g., to read or watch series). Participants responded in an open response field in a hh:mm format.

Bedtime procrastination. For each day, we calculated the discrepancy between the ideal and actual bedtime as a measure for bedtime procrastination.

Sleep duration. Participants reported the time they got up in the morning in an open response field using a hh:mm format. We calculated sleep duration for each night using the bedtime on the evening before and the time participants got up the next morning.

Sleep quality. To assess sleep quality, we asked participants, "How well did you sleep last night?" (1 = *very good* to 6 = *very bad*). The item was reverse scored such that high values represent higher sleep quality.

Daily stress. To reduce measurement error, we assessed daily stress with three indicators measured at different time points. First, participants reported their momentary stress level on four items taken from the Multidimensional Mood Questionnaire (MDBQ; Steyer, Schwenkmezger, Notz, & Eid, 1997). The question asked "How do you feel right now…tensed, nervous, calm (reverse scored), and relaxed (reverse scored). Items were averaged to one indicator of momentary stress (1 = *not at all* to 5 = *very much*, $\alpha = .82$). Second, participants reported on two items their expected stress for today and the stress they experienced yesterday (i.e., "What do you think, how stressful is today going to be?"; "Overall, how stressful was your day yesterday?"; 1 = *not at all stressful* to 5 = *very stressful*). Because indicators were measured on different response scales indicators were z-transformed before being averaged to one stress index ($\alpha = .61$). The stress retrospectively reported for the previous day was thereby averaged with momentary and expected stress

reported the day before (i.e., all stress measures related to the same day).

Bedtime procrastination scale. To prevent demand effects for the study self-reported bedtime procrastination was assessed at the end of the study in the last daily questionnaire. We translated the Bedtime Procrastination Scale introduced by Kroese et al (2014) into German. The scale consists of 9 items (e.g., "I go to bed later than I had intended", "I go to bed early if I have to get up early in the morning", reverse scored) to be rated on a 5-point Likert scale (1 = *(almost) never* to 5 = *(almost) always*). Items were averaged to one indicator of self-reported bedtime procrastination ($\alpha = .89$).

Results

Data Structure and Analyses Strategy

The dataset had a two level structure with days being nested within participants. To adequately model the dependencies within this data structure, we analysed the data using a multi-level modelling approach (Bryk & Raudenbush, 1992). All models were estimated in R (version 3.3.3, R Core Team, 2018) using the lme4 package (Bates, Maechler, Bolker, & Walker, 2015). Models were fitted with a maximum likelihood estimation procedure. The estimation of degrees of freedom in HLM is still discussed, therefore, the lme4 package does not provide *p*-values (Bates et al., 2015). Accordingly, $|ts| > 1.96$ will be interpreted as statistically significant. Model fit was determined using the MuMIn package (Barton, 2018) and the r.squaredGLMM-function which provides an estimation of the variance explained by the full model.

Before running the analyses variables were centered as follows: all trait variables at Level 2 were z-standardized (*WT, TSC, CHR*), which is equivalent to grand-mean centering. Days were centered at the first day and ranged from 0 to 9 (*DAY*). Because we were interested in the effects of stress on bedtime procrastination raw scores of stress were centered on individuals' person-mean to capture pure within-person variation ($STRESS_w$). Further, to

control for between-person effects of stress a z-standardized mean of each person was entered in the models ($STRESS_b$) (Hoffman & Stawski, 2009).

In a set of four identical models, we predicted daily bedtime, bedtime procrastination, sleep duration, and sleep quality. Equation 1.1 represents the day level, which is represented by a random intercept and a random slope for stress and day, as well as an individual error term. The intercept is predicted by variables at person level (equation 1.2). At this level the intercept is predicted by willpower theories (γ_{01}), trait self-control (γ_{02}), chronotype (γ_{03}), and person-mean stress (γ_{04}). Last, equation 1.3 represents the cross-level interaction between variations of stress at the day level (within-person) and willpower theories at the person level. Equation 1.4 represents the change over time which is not predicted by any person-level variable:

Day-Level Equations

$$Y_{ij} = \beta_{0j} + \beta_{1j}\left(STRESS\_w_{ij}\right) + \beta_{2j}\left(DAY_{ij}\right) + \varepsilon_{ij} \quad (1.1)$$

Person-Level Equations

$$\beta_{0j} = \gamma_{00} + \gamma_{01}\left(WT_j\right) + \gamma_{02}\left(TSC_j\right) + \gamma_{03}\left(CHR_j\right) + \gamma_{04}\left(STRESS\_b_j\right) + u_{0j} \quad (1.2)$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}\left(WT_j\right) + u_{1j} \quad (1.3)$$

$$\beta_{2j} = \gamma_{20} + u_{2j} \quad (1.4)$$

Descriptive Statistics

Table 1 summarizes the descriptive statistics and zero-order correlations for the main variables of the study. The time participants went to bed was centered at midnight and is specified in minutes. On average participants went to bed at 11:32 pm with a *SD* of almost 1hr. Speaking for the pervasiveness of bedtime procrastination, participants on average went to bed 45 min later than they regarded as ideal for themselves. Nevertheless, participants in

our study slept 8 hrs per night on average, which is sufficient considering general recommendations of 7 to 9 hrs sleep per night for adults (Hirshkowitz et al., 2015).

Personality measures. With regard to correlations results showed that willpower theories were negatively correlated with trait self-control, suggesting that people with a limited theory had lower trait self-control, which replicates previous findings (Bernecker et al., 2017; Job, Walton, et al., 2015). Further, willpower theories were positively associated with stress at the person and day level: Students with more of a limited theory reported more stress than students with a nonlimited theory. However, according to convention the effect sizes were small and previous studies did not find significant associations between stress and willpower theories (Bernecker & Job, 2015; Job, Walton, et al., 2015), suggesting that these effects may also be due to random error. Last, trait self-control was negatively correlated with evening chronotype—people with higher trait self-control were more likely to categorize themselves as morning types.

Bedtime procrastination scale. Replicating previous findings, the bedtime procrastination scale correlated positively with participants' bedtime, and negatively with participants' sleep duration and sleep quality (Kroese, De Ridder, et al., 2014; Kroese, Evers, et al., 2014). Further replicating previous findings, the bedtime procrastination scale was negatively correlated with trait self-control: The higher participants' trait self-control the less they reported to engage in bedtime procrastination. However, the scale was not significantly correlated with willpower theories, suggesting that people with a limited theory do not generally engage more in bedtime procrastination, but still might to so on stressful days.

Validating our daily measure of bedtime procrastination, we found that the bedtime procrastination scale positively correlated with the daily difference between ideal and actual bedtime.

Ideal bedtime. Participants ideal bedtime was not significantly correlated with willpower theories nor with trait self-control. Thus, it was not the case that students with better self-control had more challenging ideals regarding their bedtimes. However, as expected, people who considered themselves evening chronotypes reported later ideal bedtimes. Stress was not significantly correlated with people's ideal bedtime.

Hypotheses Tests

Bedtime. The results of the multilevel models predicting sleep outcomes are summarized in Table 2. The significant positive effect of days suggest that bedtimes significantly increased over the course of the study, which was probably because the second diary week was closer to the final examination period. Further, people who identified as evening chronotype reported later bedtimes. People high in trait self-control reported earlier bedtimes, while willpower theories had no main effect on bedtimes. As expected, the cross-level interaction between willpower theories and daily fluctuations in stress was significant. The pattern of the interaction is depicted in *Figure 1*. Simple slope analyses (Preacher, Curran, & Bauer, 2006) suggest that students with a nonlimited theory go to bed earlier on stressful days compared to nonstressful days, z = -6.35, SE = 2.86, t = -2.22, p = .027, while students with a limited theory have a tendency to go to bed later, but this trend was not significant, z = 3.08, SE = 3.09, t = 1.00, p = .319.

Bedtime procrastination. Next, we predicted the daily measure of bedtime procrastination using the same model (see Table 2). The effect of chronotype was not significant, while trait self-control predicted less bedtime procrastination. Willpower theories and stress both had no significant main effect on bedtime procrastination, but the stress x willpower theory interaction was significant. The pattern of the interaction is depicted in *Figure 1*. Simple slope analyses revealed that students with a nonlimited theory showed less bedtime procrastination on high versus low stress days, z = -6.36, SE = 2.86, t = -2.22, p =

.026, while students with a limited theory showed the opposite trend, $z = 3.04$, $SE = 3.09$, $t = 0.98$, $p = .325$.

Sleep duration. Next, we tested whether willpower theories and stress predicted participants' sleep duration. In this model, we additionally controlled for stress of the upcoming day, because it may cause earlier get up times and thereby shorten participants' sleep duration. Indeed, next day's stress was negatively correlated with sleep duration, $b = -0.38$, $SE = 0.06$, $t = -6.08$, $p < .05$. Results of the other predictors in the model indicated that sleep duration did not linearly change over the course of the study and that chronotype and trait self-control did not predict sleep duration. Again, willpower theories did not affect sleep duration, whereas stress did: Participants slept significantly less in nights following a stressful day. However, the interaction with willpower theories indicated that this effect was attenuated among people with a limited theory. Simple slope analyses revealed that following a high versus low stress day students with a nonlimited theory slept more, $z = -0.13$, $SE = 0.067$, $t = -1.98$, $p = .048$, while students with a limited theory slept significantly less, $z = -0.37$, $SE = 0.079$, $t = -4.65$, $p < .001$.

Sleep quality. Last, we were interested in whether willpower theories and stress also affected participants' sleep quality. Results showed that sleep quality did not change over time. Further, none of the trait measures significantly predicted sleep quality, while stress was a significant negative predictor of sleep quality on both levels of variation: Participants with high levels of stress reported lower sleep quality (between-person effect) and sleep quality was also impaired by (precedent) stressful days (within-person effect). The interactions between implicit theories about willpower and stress were both not significant suggesting that the negative effect of stress on sleep quality does not depend on people's beliefs about willpower.

Brief Discussion

Results of the first study confirm that bedtime procrastination is a pervasive phenomenon. On average, students in our sample missed their ideal bedtime by 45 minutes. Supporting the view of bedtime procrastination as case of self-control failure, we replicated the negative association between trait self-control and bedtime procrastination. However, students high versus low in trait self-control did not sleep more, because they got up earlier in the morning. This result matches the finding that people high in trait self-control regard themselves more as morning chronotypes. Over and above the effects of trait self-control, willpower theories and stress had an interactive effect on bedtime procrastination: Particularly on stressful days students who believe that their willpower is nonlimited go to bed earlier and engage less in bedtime procrastination. As a result, they get more sleep following days with high versus low stress, while students with a limited theory get significantly less sleep. Sleep quality was negatively affected by stress on the between and within-subjects level but this effect was not dependent on willpower theories.

Study 2

Study 2 aimed to replicate the findings of Study 1 in a different sample, namely in adolescents. Studying dysfunctional sleep patterns in this group is particularly relevant, because research indicates that during adolescence insufficient sleep is associated with behavioral and emotional dysregulation and performance deficits (Dahl & Lewin, 2002; Dewalda et al., 2010). We expected that adolescents who endorse more of a limited theory go to bed later and get insufficient sleep on a stressful day, whereas adolescents with a nonlimited theory might show the opposite pattern. In this study, we controlled for trait procrastination, because it has already been found to be related to bedtime procrastination

(Kroese, Evers, et al., 2014). Due to time constraints, we did not assess trait self-control in this study.

Method

We conducted a daily diary study (4 days) and collected information about students' daily sleep behavior (i.e., bedtime, get-up time, sleep duration, sleep quality) and stress using a paper-pencil survey administered in school in the morning classes. In exchange for participation students received sweets and had the chance to win one out of two cinema tickets per class. The study was approved by the institutional review board.

Participants and Procedure

A total of $N = 137$ (51.1% female, $M_{age} = 14.41$ years, $SD_{age} = 0.60$) students participated. The majority of students were from 8th grade (91.2%), while only a minor proportion were from from 9th grade (7.3%), and 7th grade (1.5%). Out of 548 daily questionnaires students returned $n = 511$ (93.2%) with an average of $M = 3.73$ ($SD = 0.57$, Range: 2–4) per student. Post-hoc power analyses with 1000 simulated studies suggest that the power for detecting the predicted cross-level interaction on the main outcome bedtime procrastination was .72.

The study was advertised in four secondary schools in [omitted for reason of anonymity]. Overall, 11 teachers were approached via email and telephone and informed about the purpose and procedure of the study; 10 agreed to take part and manage the data collection in their classes. The experimenter visited all classrooms and explained the study's purpose and procedure to students. Because students were under the age of 16 their parents had to provide the informed consent in a letter taken home by the students. The paper-pencil questionnaires were administered between 7:00 and 11:30 am in class. Teachers were instructed to ensure that students did not communicate while completing the questionnaires. On Monday students filled in the initial questionnaire with measures of personality traits and

ideal bedtime. From Tuesday to Friday students filled in four identical questionnaires collecting information about sleep behavior and stress.

Measures of the Initial Questionnaire

We used the same items as described in Study 1 to assess willpower theories (α = .64), bedtime procrastination (α = .85), and ideal bedtime (1 item).

Trait procrastination. Additionally, trait procrastination was assessed with the German version of the Tuckman Procrastination Scale (Ströber, 1995; Tuckman, 1991) consisting of 11 items and assessed procrastination in different areas such as work (e.g., "I postpone tasks, although they may be important", reverse scored) or decisions (e.g., "I postpone difficult decisions", reverse scored). Items were rated on a 5-point scale (1 = *very much* to 5 = *not at all*) and averaged to one scale (α = .82).

Measures of the Daily Questionnaires

We used the same measures as described in Study 1 to assess *stress*, *bedtime*, get-up time, and *sleep quality* in the daily questionnaires. Further, we calculated the *discrepancy* between ideal and actual bedtime and the *sleep duration* per night as described in Study 1.

Results

Data structure and Preparation

We applied the same multilevel modelling approach as described in Study 1. Again, all trait variables were z-standardized (*WT, PROC*) which compares to grand-mean centering. Raw scores of stress were centered on the person-mean to capture within-person variation ($STRESS_w$) and the person mean in stress was grand-mean centered to control for between-person effects of stress ($STRESS_b$). Because time did not have a significant effect on any outcome in this study it was not controlled in the day level equation. Therefore, model equations were as follows:

Day-Level Equations

$$Y_{ij} = \beta_{0j} + \beta_{1j}\left(STRESS\_w_{ij}\right) + \varepsilon_{ij} \quad (1.1)$$

Person-Level Equations

$$\beta_{0j} = \gamma_{00} + \gamma_{01}\left(WT_j\right) + \gamma_{02}\left(PROC_j\right) + \gamma_{03}\left(STRESS\_b_j\right) + u_{0j} \quad (1.2)$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}\left(WT_j\right) + u_{1j} \quad (1.3)$$

Descriptive Statistics

Table 3 represents descriptive statistics and zero-order correlations at person and at day level for all variables in the study. Overall, high school students in our sample went to bed at 11:34 pm with a *SD* of 1 hr and slept less than 7 hours, which is not sufficient following recommendations of 8-10 hours (Hirshkowitz et al., 2015).

Bedtime procrastination scale. Speaking for the validity of the bedtime procrastination scale also in this age group, we found that bedtime procrastination was positively correlated with bedtimes, the discrepancy measure of bedtime procrastination, and negatively correlated with sleep duration and sleep quality. In this sample, the bedtime procrastination scale was positively related to a limited theory about willpower and to overall levels of stress.

Ideal bedtime. On average, students reported an ideal bedtime of 9:54 pm implicating that they regard sufficient sleep as important. Trait procrastination and stress were both not significantly correlated with ideal bedtimes, however, in this sample, ideal bedtimes were positively correlated with willpower theories, suggesting that students with a limited theory regard later bedtimes as ideal.

Hypotheses Tests

Bedtime. The results of the multilevel models predicting sleep outcomes are

summarized in Table 4. Trait procrastination did not predict students' bedtimes. Replicating the findings of Study 1, there was no main effect of willpower theories. However, the within-person effect of stress was positive and significant in this study—on stressful days students went to bed later. As expected, the cross-level interaction between willpower theories and daily stress was significant. The pattern of the interaction is depicted in Figure 2. Simple slope analyses confirmed that it were particularly students with a limited theory (+1 SD) went to bed later on stressful versus nonstressful days, $z = 18.12$, $se = 5.83$, $t = 3.11$, $p = .002$, while stress (+1 unit) did not affect bedtime among nonlimited students, $z = -0.96$, $se = 6.01$, $t = -0.16$, $p = .879$.

Bedtime procrastination. Mirroring the results for bedtimes, bedtime procrastination was predicted by day level stress and its cross-level interaction with willpower theories. Simple slope analyses confirmed that students with a limited theory procrastinate on going to sleep particularly on stressful days, $z = 19.58$, $se = 5.74$, $t = 3.41$, $p = .001$, while students with a nonlimited theory showed the same bedtime procrastination independent of daily stress, $z = -0.27$, $se = 3.41$, $t = -0.05$, $p = .964$ (see Figure 2).

Sleep duration. Replicating the findings of Study 1, sleep duration was significantly predicted by the cross-level interaction between willpower theories and day level stress. Students with a limited theory slept significantly less after a stressful versus less stressful day, $z = -0.33$, $se = 0.12$, $t = -2.76$, $p = .006$, while students with a nonlimited theory slept the same amount independent of day level stress, $z = 0.07$, $se = 0.12$, $t = 0.55$, $p = .583$.

Sleep quality. Replicating the results of Study 1, sleep quality was impaired by stress on the person and the day level. Willpower theories had no main effect on sleep quality and also the interaction between willpower theories and day level stress was not significant.

Brief Discussion

The findings of Study 2 suggest that sleep procrastination is a prevalent phenomenon also in adolescents. On average, high school students in our study missed their ideal bedtime by 1.5 hours. With regard to predictors of bedtime procrastination, we again found that willpower theories and daily stress have an interactive effect. Students with a limited theory went to bed later on stressful days and as a result slept significantly less. Replicating the findings of Study 1, sleep quality was significantly reduced on stressful days and among students with high stress levels and these effects were independent of willpower theories. Trait procrastination was positively related to self-reported bedtime procrastination but did not predict any of the daily sleep outcomes, suggesting that some of the overlap with the bedtime procrastination scale might be due to common method variance.

General Discussion

While past research has documented adverse effects of stress on sleep quality (Burgard & Ailshire, 2009; Knudsen, Ducharme, & Roman, 2007), the present study shows that depending on the beliefs people hold about their willpower stress may also affect their sleep duration. The results of two daily diary studies suggest that bedtime procrastination is a pervasive phenomenon among college and high-school students. College students in Study 1 met their ideal bedtime in 20% of days and slept less than 7 hours in 18% of days. High-school students in Study 2 met their ideal bedtime only in 5% of days and slept less than 7 hours in 42.7% of days and less than the recommended 8 hours in 73.5% of days.

Advancing previous knowledge about predictors of bedtime procrastination the present research focused on willpower theories and stress. Results of two daily diary studies suggest that students' bedtime procrastination and their sleep duration depend on the interplay between students' daily stress levels and their willpower theories. The pattern of the

interaction differed slightly between studies: While in Study 1, it were students with a nonlimited theory who went to bed *earlier* on stressful days as compared to nonstressful days, in Study 2, students with a limited theory went to bed *later* on stressful days than on nonstressful days. Apparently, stress may relate to two kinds of sleep-related responses: some people procrastinate more on their bedtime (adolescents with a limited theory), while others go to bed earlier (students with a nonlimited theory). We may only speculate, whether age or overall level of bedtime procrastination, which was higher in the adolescents' sample play a moderating role. Future research should therefore explore the conditions that lead to the emergence of these two kinds of stress responses in people with a limited versus nonlimited theory about willpower.

Further, in both samples we found that sleep quality was undermined by daily stress, an effect that replicates previous findings (e.g., Burgard & Ailshire, 2009) and was independent of students' willpower theories. Thus, willpower theories seem not to affect sleep quality but rather sleep duration. This suggests that limited theorists are not necessarily more disturbed emotionally by a stressful day as compared to nonlimited theorists. Once they manage to get to bed they can sleep equally well.

In both studies, we included additional trait-level predictors of bedtime procrastination (i.e., trait self-control, trait procrastination, chronotype) to demonstrate the incremental value of willpower theories in predicting bedtime procrastination. In Study 1, we controlled for trait self-control and chronotype and found that students with high trait self-control engaged less in bedtime procrastination which replicates previous findings (Kroese, De Ridder, et al., 2014; Kroese, Evers, et al., 2014). Interestingly, however, students with high trait self-control did not get more sleep overall, because they got up earlier in the mornings. Likewise, trait self-control was also related to self-reported "morningness". This finding is new and might point to a psychophysiological basis for the positive effects of trait self-control on academic/job

performance (Tangney et al., 2004). Namely, people with high trait self-control are more likely to have a chronotype that matches with societal standards in terms of work/study hours. Future research should take chronotype into account when studying effects of trait self-control on performance.

Possible Mechanisms

One question that the present research did not address is *why* people with a limited theory engage in more bedtime procrastination after a stressful day. There are several plausible mechanisms. Based on previous research, one could assume that people with a limited theory think that they lack the resources to start the aversive evening routine (Nauts et al., 2016). Another reason might be that limited theorists have a greater need to recover from a stressful day and therefore prolong relaxing activities into the night. Previous research documented that exerting self-control triggers the goal to rest and leads to more resting behavior in people with a limited theory (Job, Bernecker, Miketta, & Friese, 2015). It may seem paradoxical that somebody who wants to recover procrastinates on going to sleep. After all, sleep seems to be the best activity to actually recover. However, people do not experience the recovering effect of sleep until the next morning, while they immediately experience the relaxing effect of, for instance, watching TV or working out (Sonnentag, 2001, 2003). A third mechanism may be that limited theorists study or work long into the night instead of going to bed. Previous research showed that a limited theory is related to academic procrastination especially if people are highly stressed (Job et al., 2010; Job, Walton, et al., 2015). Possibly limited theorists try to make up for what they have postponed during the day and therefore end up sleeping less. However, this behavior might even be adaptive in terms of stress regulation and might thereby foster sleep quality.

For the examination of possible mechanisms, a fruitful approach for future research might therefore be to focus on the activities people do instead of going to bed and to closer

examine what they get out of these activities. Research suggests that activities that allow people to relax and detach from their work have positive effects on morning affectivity over and above effects of sleep duration and sleep quality (Sonnentag, Binnewies, & Mojza, 2008). While the type of leisure activity seems to be important for relaxation the duration of such activities should play a role as well. At the end of the day, people may face a trade-off between spending sufficient time to recover versus getting sufficient sleep. In fact, this trade-off may be even more complex, because being recovered before going to bed may contribute to people's sleep quality. Perhaps, activities that serve evening recovery buffer adverse effects of stress on sleep quality (Burgard & Ailshire, 2009; Knudsen et al., 2007), while on the other hand they may reduce sleep duration, if prolonged into the late night.

Limitations

The present studies tested the hypotheses in two young samples of college and high-school students and, therefore, the findings may not generalize to working adults. Another limitation is the measurement of sleep quality and bedtime using self-reports. As sleep quality was not the main outcome of the study, we assessed it with one item only. However, even with this one item assessment, we replicated previous findings regarding adverse effects of stress (Burgard & Ailshire, 2009; Knudsen et al., 2007). To get more reliable measures of bedtime wearable accelerometers or data from people's smartphones might be an alternative. However, because participants reported their bedtime in the next morning and were not aware of the purpose of the study we regard their reports as relatively unbiased in terms of memory and demand effects (e.g., Furnham, 1986).

Conclusion

A vast amount of studies show the significance of sleep for cognitive performance, as well as for physical and mental health (e.g., Buxton & Marcelli, 2010; Sabanayagam & Shankar, 2010; Stickgold, 2001). Bedtime procrastination is a pervasive self-control problem

that contributes to insufficient sleep (Kroese, Evers, et al., 2014). The present research suggests that bedtime procrastination is interactively affected by people's daily stress levels and their willpower theories: When experiencing high levels of stress, students with a limited versus nonlimited theory procrastinate more on their bedtime and as a result get less sleep. This seems to be a highly dysfunctional strategy, because sleep should be the best way to recover. Because sleep is related to successful self-control (Hagger, 2010), the additional amount of sleep may also explain why students with a nonlimited theory show better self-control and experience higher subjective well-being in demanding phases of life as compared to students with a limited theory (Bernecker et al., 2017; Job, Walton, et al., 2015).

Footnote

[1] In Study 1, we additionally assessed conscientiousness and mindfulness as possible third variables. Analyses showed that both did not predict any of the outcomes under study and that including them in the models did not change results reported here. For the purpose of readability results for conscientiousness and mindfulness are not reported here.

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Table 1

Descriptive Statistics and Zero-Order Correlations for Main Variables of Study 1 (N = 185)

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9
1. Willpower theories	2.95	0.80				.11			.10	.15	.02
2. Trait self-control	3.86	0.63	-.39			-.02			-.23	-.17	.03
3. Chronotype	2.76	0.92	.00	-.27		-.03			.35	.10	-.08
4. Stress	0.01	0.48	.19	-.07	-.05		.04	-.08	-.02	.03	-.15
5. Btp scale	3.24	0.84	.06	-.39	.54	.08			.39	.20	-.14
6. Ideal bedtime	-73.43	45.83	-.07	-.10	.38	-.10	.29		.37	-.28	-.17
7. Bedtime	-28.94	54.12	.15	-.34	.47	.08	.54	.49		.79	-.43
8. Btp discrepancy	42.73	70.27	.23	-.27	.16	.17	.29	-.38	.62		-.34
9. Sleep duration	8.05	0.70	.03	.09	-.15	-.11	-.28	-.34	-.56	-.28	
10. Sleep quality	3.61	0.54	-.08	.11	-.08	-.36	-.16	.02	-.12	-.15	.03

Note. BtP = Bedtime procrastination. Correlations below diagonal represent person-level correlations with $r(185) > |.16|$, $p < .05$. Correlations above diagonal represent day-level correlations with $r(1546) > |.05|$, $p < .05$.

Table 2

Results of Random-Intercept-Random-Slope Models Predicting Sleep Outcomes in Study 1 (N = 185)

	Bedtime			Bedtime Procrastination			Sleep Duration			Sleep Quality		
Predictor	*b*	*SE*	*t*	*b*	*SE*	*t*	*b*	*SE*	*t*	*b*	*SE*	*t*
Fixed Effects												
Intercept	-35.72	4.10	-8.72	37.97	4.23	8.98	7.99	0.07	111.50	3.56	0.05	71.67
Time	**1.37**	**0.48**	**2.82**	**1.43**	**0.48**	**2.96**	0.02	0.01	1.59	0.01	0.01	1.65
Chronotype	**23.23**	**3.73**	**6.23**	6.06	3.89	1.56	-0.08	0.05	-1.57	-0.04	0.04	-0.94
Trait self-control	**-10.63**	**4.02**	**-2.65**	**-8.73**	**4.19**	**-2.08**	0.04	0.06	0.62	0.05	0.04	1.12
Willpower theories (WT)	3.25	3.92	0.83	6.32	4.09	1.55	0.05	0.06	0.95	0.01	0.04	0.21
Stress *between*	3.49	3.55	0.99	7.03	3.70	1.90	-0.08	0.05	-1.48	**-0.19**	**0.04**	**-5.03**
Stress *within*	-3.26	2.45	-1.33	-3.22	2.45	-1.32	**-0.39**	**0.06**	**-6.84**	**-0.28**	**0.04**	**-6.28**
WT*Stress *within*	**6.18**	**2.44**	**2.54**	**6.17**	**2.44**	**2.53**	**-0.13**	**0.06**	**-2.38**	0.01	0.04	0.27
Random Effects (SD)												
Intercept	42.06			44.17			0.53			0.41		
Stress *within*	0.10			-0.01			0.91			0.21		
Residual	52.34			52.33			1.26			0.80		
R^2 *full model*	0.49			0.46			0.19			0.30		

Note. Effects that are significant at $p < .05$ are printed in bold.

Table 3

Descriptive Statistics and Zero-Order Correlations for Main Variables of Study 2 (N = 137)

Variable	*M*	*SD*	1	2	3	4	5	6	7	8
1. Willpower theories	3.07	0.78			.08			.09	.01	-.04
2. Trait procrastination	2.97	0.69	.26		.06			.10	.03	-.09
3. Stress	2.33	0.67	.14	.10		.14	.01	.14	.13	-.14
4. Btp scale	3.34	0.83	.36	.41	.22			.29	.20	-.28
5. Ideal bedtime	-125.80	50.15	.19	.10	.05	.14		.19	-.37	-.14
6. Bedtime	-26.98	59.33	.11	.14	.18	.41	.28		.84	-.88
7. Btp discrepancy	98.40	66.02	-.03	.06	.12	.26	-.51	.68		-.76
8. Sleep duration	6.88	1.01	-.03	-.13	-.19	-.40	-.18	-.86	-.64	
9. Sleep quality	3.54	0.78	-.19	-.17	-.38	-.29	-.06	-.40	-.31	.42

Note. Btp = Bedtime procrastination. Correlations above diagonal represent day-level correlations with $r > |.09|$ being significant at $p < .05$. Correlations below diagonal represent person-level correlations with $r > |.17|$ being significant at $p < .05$.

Table 4

Results of Random-Intercept-Random-Slope Models Predicting Sleep Outcomes in Study 2 (N = 137).

	Bedtime			Bedtime Procrastination			Sleep Duration			Sleep quality		
Predictor	*b*	*SE*	*t*	*b*	*SE*	*t*	*b*	*SE*	*t*	*b*	*SE*	*t*
Fixed Effects												
Intercept	-27.00	4.89	-5.52	99.10	5.65	17.54	6.87	0.08	83.18	3.53	0.22	58.90
Willpower theories (WT)	5.61	5.11	1.10	-1.69	5.86	-0.29	-0.03	0.09	-0.31	-0.09	0.06	-1.42
Trait procrastination	6.67	5.07	1.32	3.79	5.73	0.66	-0.14	0.09	-1.66	-0.10	0.06	-1.55
Stress *between*	6.94	4.88	1.42	5.96	5.52	1.08	-0.15	0.08	-1.80	**-0.27**	**0.06**	**-4.45**
Stress *within*	**8.58**	**4.22**	**2.04**	**9.66**	**4.16**	**2.32**	-0.13	0.09	-1.54	**-0.16**	**0.05**	**-3.02**
WT*Stress *within*	**9.54**	**4.15**	**2.30**	**9.93**	**4.06**	**2.45**	**-0.20**	**0.09**	**-2.34**	-0.06	0.05	-1.08
Random Effects												
Intercept	45.76			55.82			0.78			0.51		
Stress *within*	21.69			20.49			0.60			0.19		
Residual	64.97			65.04			1.09			0.92		
R^2 *full model*	0.39			0.46			0.44			0.44		

Note. Effects that are significant at $p < .05$ are printed in bold.

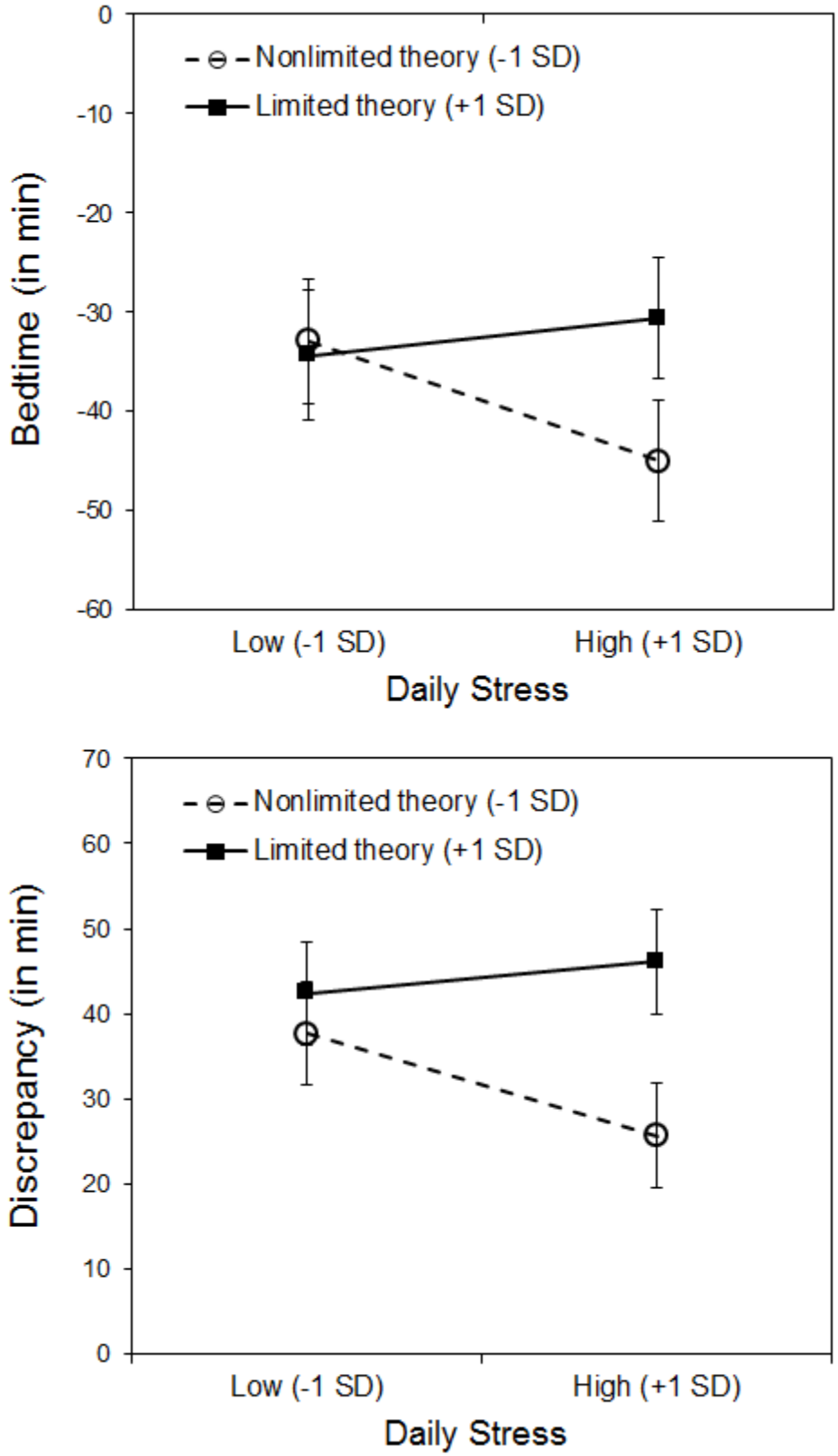
0
-10
-20
-30
-40
-50
-60
Bedtime (in min)
Nonlimited theory (-1 SD)
Limited theory (+1 SD)
Low (-1 SD)
High (+1 SD)
Daily Stress
70
60
50
40
30
20
10
0
Discrepancy (in min)
Nonlimited theory (-1 SD)
Limited theory (+1 SD)
Low (-1 SD)
High (+1 SD)
Daily Stress

Figure 1.

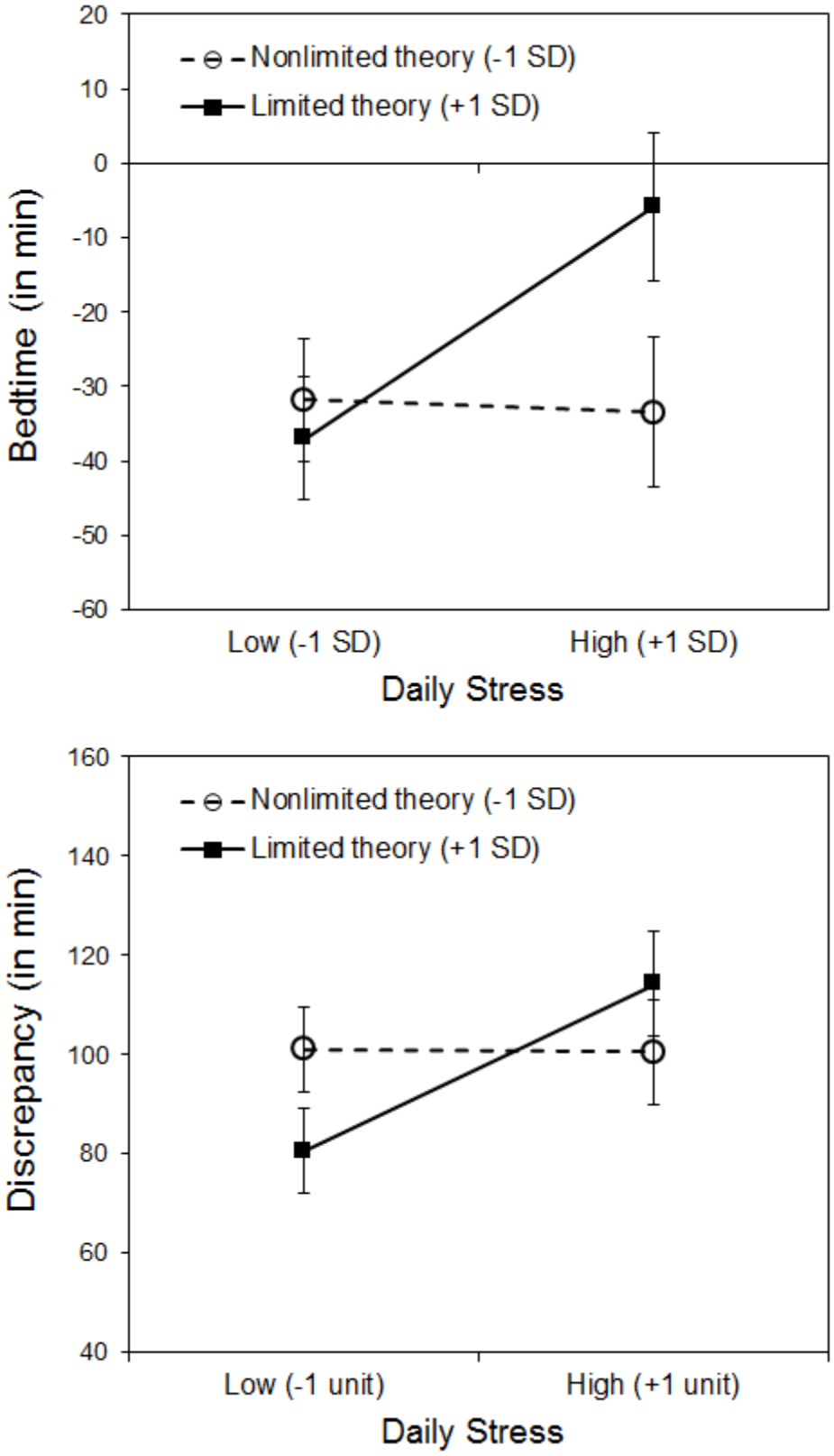
Nonlimited theory (-1 SD)
Limited theory (+1 SD)
Bedtime (in min)
20
10
0
-10
-20
-30
-40
-50
-60
Low (-1 SD)
High (+1 SD)
Daily Stress
Nonlimited theory (-1 SD)
Limited theory (+1 SD)
Discrepancy (in min)
160
140
120
100
80
60
40
Low (-1 unit)
High (+1 unit)
Daily Stress

Figure 2.

Figure Captions

Figure 1. Cross-level interaction for daily stress fluctuations and willpower theories on bedtime (top) and discrepancy between actual and ideal bedtime (bottom) in Study 1.

Figure 2. Cross-level interaction for daily stress fluctuations and willpower theories on bedtime (top) and discrepancy between actual and ideal bedtime (bottom) in Study 2.