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# Using mental contrasting with implementation intentions to reduce bedtime procrastination: two randomised trials

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**ABSTRACT**

**Objective**: The importance of getting a good night sleep is critical, yet for many this remains elusive. Bedtime procrastination—the notion that people delay going to bed for no legitimate reason—is one area that has received little attention, despite its associations with worse sleep outcomes. In the present research, we investigated how to effectively self-regulate bedtime procrastination.

**Design**: In two studies (N1 = 383, N2 = 221), undergraduate students participated either in an online self-regulation exercise called mental contrasting with implementation intentions (MCII) or a motivationally-relevant control exercise (Study 1) or a sleep hygiene control group (Study 2). We then assessed outcomes three weeks (Study 1) or one week (Study 2) later.

**Main Outcome Measures**: We assessed commitment to reduce bedtime procrastination and self-reported bedtime procrastination using two different measures.

**Results**: We found that MCII (compared to control) increased commitment to reduce bedtime procrastination. In both studies this corresponded to a reduction in the average minutes of bedtime procrastination per night.

**Conclusion**: MCII is a simple and cost-effective self-regulation tool for reducing bedtime procrastination. Future research should seek to reveal the mechanisms that undergird bedtime procrastination, as well as understand the present findings in other populations and contexts.

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Self-regulation; sleep; procrastination; motivation; mental contrasting with implementation intention

The importance of getting a good night sleep is critical. The image of the groggy and unproductive employee is easy to conjure and difficult to ignore;failure to get a good night sleep is so frequent that it has become a public health issue (Gradisar et al., 2013). Insufficient sleep increases the likelihood of suffering from noncommunicable diseases such as hypertension, diabetes, depression and obesity, as well as an increased likelihood of mortality and cancer (Connor et al., 2002; Gangwisch, 2009; Roane & Taylor, 2008; Strine & Chapman, 2005). Moreover, insufficient sleep is known to be linked to an increase in motor vehicle crashes, industrial disasters, occupational

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errors and other workplace detriments (Belenky et al., 2003; Connor et al., 2002; Curcio, Ferrara, & De Gennaro, 2006).

Although there are a multitude of factors undermining good sleep—ranging from inadequate sleep quantity to poor sleep quality—procrastination is one aspect that may be of particular importance. General procrastination has been linked to worse health, reduced well-being and is even directly associated with worse sleep (Kroese & de Ridder, 2016; Sirois, 2007; Tice & Baumeister, 1997). However, recent work suggests that targeting procrastination specific to bedtime behaviours (as opposed to more general procrastination) may be an effective way to improve sleep sufficiency. Bedtime procrastination is typically defined as going to bed later than intended without any legitimate reason causing the delay (Kroese, de Ridder, Evers, & Adriaanse, 2014; Kroese, Evers, Adriaanse, & de Ridder, 2016). Above and beyond the effects of general procrastination, self-regulation and other demographic factors including chronotype preference, bedtime procrastination has been found to be associated with worse sleep overall (Kroese et al., 2014, 2016) demonstrating that it may be an especially relevant problem area in the pursuit of a good night sleep (Hagger, 2009; Kühnel, Syrek, & Dreher, 2018).

While the detrimental effects of bedtime procrastination on sleep sufficiency are well demonstrated throughout the literature, their underlying reasons are still unclear. One possibility is that the activities associated with bedtime procrastination disrupt the soothing process of 'winding down' before going to bed. In line with this reasoning, Nauts, Kamphorst, Sutu, Poortvliet, and Anderson (2016) observed that bedtime routine aversion leads to increased bedtime procrastination. Another possible factor in bedtime procrastination is excessive media usage. Recent research supports the idea that self-regulatory failure in nightly media consumption underlies bedtime procrastination (Exelmans & van den Bulck, 2016). While continuing to explore the causes associated with bedtime procrastination may guide the development of respective interventions, the absence of a clear consensus on what makes people engage in bedtime procrastination suggests that the root of the problem may be driven by a range of different causes. Accordingly, the creation of powerful interventions to reduce bedtime procrastination needs to explicitly consider this plurality. Critically, we focus on the behaviours that comprise bedtime procrastination, with an eye towards giving people who wish to go to bed on time the necessary strategies to downregulate.

## Interventions for improving sleep sufficiency

Despite recent calls for the development of interventions to improve sleep sufficiency (particularly reducing bedtime procrastination), research on the effectiveness of different kinds of interventions is still scarce (Kroese et al., 2014, 2016). Sleep intervention research focuses on certain developmental contexts (especially those related to sleep education), older adult samples, people with special work demands (e.g. pilots and nurses) and people with physical illness or sleep disorders. However, because bedtime procrastination is also a nonclinical problem, interventions for nonclinical samples should also be developed. Sleep intervention research in general (nonclinical) adult

populations has been relatively sparse compared to research focusing on more select samples (Briones et al., 1996). In the present research, we aimed to address this gap.

Still, some intervention research has been conducted in the context of improving sleep quality and fostering good sleep hygiene practices in healthy adults. Most commonly, providing information about the importance of enough sleep is considered among the best strategies available to mitigate sleep insufficiency in college students and adults (Brown, Buboltz, & Soper, 2002). However, this strategy has not garnered convincing support beyond a few modest effects (Irish, Kline, Gunn, Buysse, & Hall, 2015). Because providing information and facts about health behaviour is such a frequently deployed strategy—and one that is both cost and time effective—its effects represent an important benchmark that must be surpassed in the use of any alternative interventions. Outside of simply providing information to improve sleep, a number of interventions have been used to enhance sleep hygiene. Sleep hygiene is regularly considered in the treatment of sleep disorders and refers to 'recommendations [that] are generally aimed at having the individual avoid behaviour that interferes with a normal sleep pattern, or to engage in behaviour that promotes good sleep' (p. 215; Stepanski & Wyatt, 2003). Although sleep hygiene is a broader construct encompassing many types of behaviours, conceptual and theoretical similarities make it a potentially useful concept in the development of strategies for reducing bedtime procrastination. For example, Loft and Cameron (2013) compared an implementation intentions intervention to an emotional arousal technique and found that implementations intentions improved sleep behaviour for daytime employees, but no such effect was found for the emotional arousal technique. Similarly, Mairs and Mullan (2015) examined the effects of a self-monitoring versus implementation intentions intervention and found some support for both, but ultimately concluded that the effects of implementation intentions were stronger. Importantly, Mairs and Mullan (2015) gave participants 8 different implementation intention plans, each for a different targeted sleep behaviour. However, providing so many specific implementation intentions may have induced conflict regarding which plans to prioritise such that the strength of the implementation intentions formed may even have been underestimated.

The self-regulation strategy of mental contrasting with implementation intentions (MCII) may be especially well-suited to develop an intervention for mitigating bedtime procrastination. MCII is an intervention that has been successfully deployed in various health domains but has not been examined in sleep research yet. For reasons which we focus on and explicate in the present research section below, MCII may be particularly effective at attenuating bedtime procrastination.

## Mental contrasting with implementation intentions (MCII)

The self-regulation strategy of MCII has been successful in improving various health behaviours that are difficult to control (e.g. healthy eating, regular physical exercise, stress and pain reduction; summaries by Oettingen, 2012, 2014; Oettingen & Gollwitzer, 2010). MCII is an evidence-based, process-oriented amalgamation of two previously-supported self-regulation tools—MCII. MCII combines the benefits of both targeting goal pursuit (goal commitment and goal striving), as well as goal

implementation when faced with particularly difficult goals (e.g. conquering strong impulses or bad habits). We describe both processes below.

### *Mental contrasting*

Mental contrasting is a self-regulation strategy that facilitates goal pursuit via cognitive and motivational mechanisms. In mental contrasting, people first name an important wish (e.g. getting to bed on time) and then identify and mentally elaborate the best outcome (e.g. feeling well-rested). They then identify and vividly imagine a central inner obstacle to reaching that future (e.g. the urge to keep watching videos on the internet). Mental contrasting produces associative links between the desired future and the obstacle of present reality, as well as the obstacle and the instrumental behaviour to overcome this obstacle (Kappes & Oettingen, 2014; Kappes, Singmann, & Oettingen, 2012). The mental associations forged in the process of engaging in mental contrasting predict effort (Oettingen et al., 2009) and readiness to plan how to overcome the obstacle (Kappes, Wendt, Reinelt, & Oettingen, 2013; Oettingen, Pak, & Schnetter, 2001).

Research has shown that the specific sequence (first thinking about a desired wish followed by a critical obstacle) is crucial for nurturing goal pursuit. Participants randomly assigned to control groups focusing on component parts alone (*just* positive outcome or *just* obstacle) or an alternative order (thinking about an obstacle first followed by a positive outcome) showed weaker goal pursuit (Oettingen et al., 2001). Importantly, people must have reasonable expectations regarding fulfilling the desired wish—when expectations of success are low, research shows that goal pursuit will actually decrease because people start to disengage from their wishes (Oettingen, 2000, 2012). The effectiveness of using mental contrasting to facilitate behaviour change has been demonstrated across a wide variety of domains and settings (summary by Oettingen, 2014). Moreover, these effects are not only short term—enhanced goal pursuit and increased performance has been shown to persist over longer periods of time (i.e. weeks, months and even years; Stadler, Oettingen, & Gollwitzer, 2009, 2010).

### *Implementation intentions*

Mental contrasting, though capable of facilitating goal pursuit and attainment on its own, can be paired with implementation intentions, or 'if-then' plans, in order to further facilitate goal attainment. When an obstacle is especially difficult to deal with, implementation intentions can be of help by automating goal striving (Gollwitzer, 1999, 2014). Implementation intentions detail when, where and how a goal intention ('I intend to get to bed on time') should be executed ('If it is 11:00pm, then I will stop with whatever I am involved with and get ready for bed!'). If-then plans increase the accessibility of a given obstacle specified by the 'if' part of the plan (e.g. Achtziger, Bayer, & Gollwitzer, 2012; Parks-Stamm, Gollwitzer, & Oettingen, 2007; Webb & Sheeran, 2007), and they foster automatic and effortless goal-directed responses specified by the 'then' part when the obstacle is actually encountered (e.g. Bayer, Achtziger, Gollwitzer, &

Moskowitz, 2009; Gollwitzer & Brandstätter, 1997). Experimental work on implementation intentions has demonstrated an increased behavioural readiness, and this effect has been shown across a wide array of behaviours in the health, achievement and interpersonal domain (Gollwitzer, 2014; Gollwitzer & Sheeran, 2006; Sheeran, Milne, Webb, & Gollwitzer, 2005).

## Aims and hypotheses of the present research

Sleep interventions commonly impose a paternalistic solution applicable to *only* sleep problems. However, research demonstrates that people prioritise their goals differently (Locke & Latham, 2002) and have different bedtime preferences (Baehr, Revelle, & Eastman, 2000), suggesting the necessity for self-regulatory interventions to be easily tailored to the personal wishes and problems of the targeted populations. MCII provides exactly that, helping people to translate their personal wishes into action. In particular, MCII facilitates mentally experiencing one's desired future and then discovering and imagining one's most critical inner obstacle that stands in the way. People can then make if-then plans that specify how these obstacles shall be overcome once they are encountered. Given the ambiguous nature of the underlying causes and mechanisms of bedtime procrastination, the flexible nature of MCII makes it an ideal candidate for effectively alleviating bedtime procrastination because MCII is a content-free strategy to be content-specified by the individual who uses it.

## Study 1

In the present study, we aim to reduce the amount of time individuals spend procrastinating going to bed. Thus, we sought to investigate the effects of MCII on reducing bedtime procrastination by establishing two intervention conditions. As information about sleep insufficiency (e.g. potential health and social consequences of insufficient sleep) seemed necessary in order to decrease variance in knowledge differences (Brown, Buboltz, & Soper, 2002), participants in both intervention groups first received information about the importance of sleep sufficiency. Participants in the information + MCII group then also learned a self-regulation technique—MCII. Participants in the information + positive thinking group were instead taught to use a positive thinking strategy. We elected to use this control group because previous research in motivation psychology has shown that positive thinking serves as an experimentally rigorous motivational control condition (summaries by Oettingen, 2012, 2014). All aspects of the positive thinking control are nearly identical to the MCII control condition—the only difference is that participants in the MCII condition think about an obstacle rather than two positive outcomes. All participants were encouraged to use these self-regulation strategies regularly and as often as they saw fit for the duration of the 3-week long study.

Accordingly, we hypothesised that MCII, relative to a positive thinking control condition, will (a) increase commitment to the goal of reducing bedtime procrastination and (b) lead to reduced bedtime procrastination. More specifically, with respect to goal commitment, we hypothesised a main effect of intervention type (MCII v. positive

thinking) qualified by an interaction effect with time, such that participants will not differ at baseline, but those who use MCII will be more committed directly after the intervention, as well as after 3 weeks. Predictions for attainment of reduced bedtime procrastination are similar; we hypothesised a main effect for intervention type qualified by an interaction effect, such that participants will not differ in reported levels of bedtime procrastination at baseline, but participants who used MCII (compared to positive thinking control condition) will report reductions in bedtime procrastination after 3 weeks.

## Methods

### *Participants*

We conducted a power analysis for a two-way mixed ANOVA model to determine power for detecting the effect of the MCII intervention relative to a positive thinking control condition. Assuming a medium correlation among repeated measures ($r = .30$) and a two-tailed significance test ($\alpha = .05$), we opted for a 90% chance of detecting a small between-by-within interaction effect ($f^2 = .10$) by using a final sample size of $N = 370$. In order to allow for attrition (at a modest rate of 25%), we recruited students $N = 510$ who wished to reduce their bedtime procrastination. We recruited participants at a large US university via the psychology student online participant pool—our recruitment flier simply stated: 'Do you stay up too late at night'? Our sample had 30 participants who were currently being treated for a sleep disorder or who worked a night shift; however, there were no observed differences in any of the baseline characteristics so they were retained in our final sample. Figure 1 presents a flow diagram of our recruitment, randomisation and experimental procedures.

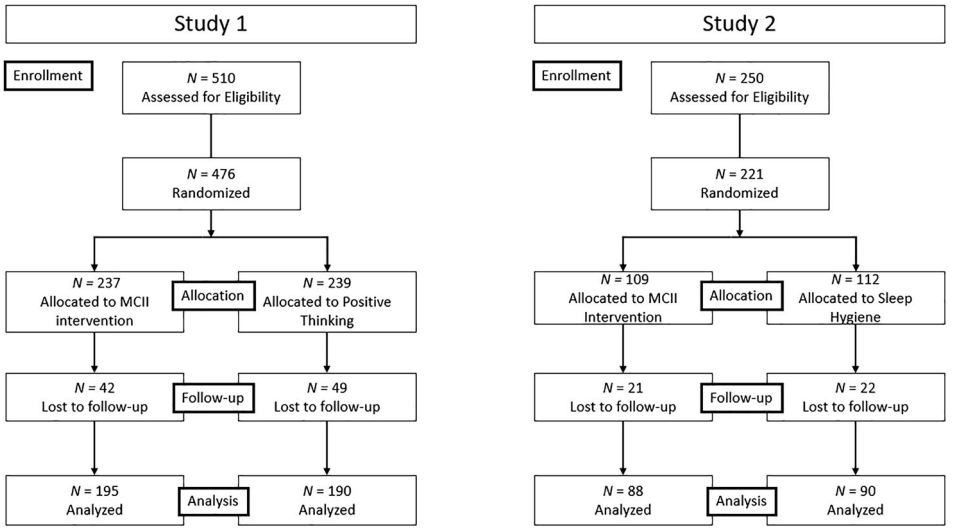


**Figure 1.** Flow diagram describing study procedure including: recruitment, randomisation, and those lost to follow-up, and final sample analysed for Study 1 and Study 2.

### Procedure

Data were collected over two time points and all subjects were assigned into one of two conditions (MCII vs. positive thinking). At baseline, participants first answered various questions about their sleep habits, about their commitment to reducing bedtime procrastination, and various background variables (see below). We then assessed bedtime procrastination using two methods which we describe below. Next, participants read information about the importance of sufficient sleep and were then randomly assigned to either an MCII condition or a positive thinking control condition. Determination of whether a participant was assigned to MCII or positive thinking was made by our survey software's (Qualtrics) built-in randomisation feature. The details of this randomisation process were unknown to the investigators and all study personnel. Both interventions were administered online and designed as parallel interventions in all aspects. The only difference between the two interventions was that participants in the information + positive thinking group learned a different strategy than the participants in the information + MCII group. Three weeks after the intervention, participants filled out the same series of questions that they had completed during baseline. All study personnel and participants were blinded to treatment assignment for the duration of the study. Only the lead author saw unblinded data following completion of data collection.

### Information + MCII intervention condition

Instructions in the MCII condition consisted of two parts: an information portion where participants read a page of facts and statistics derived from CDC and the Mayo Clinic informational websites. The information on this page detailed the importance of sleep and the potentially harmful ramifications of insufficient sleep. Next, participants learned MCII following the sequence used in prior research (e.g. Adriaanse et al., 2010; Gollwitzer, Mayer, Frick, & Oettingen, 2018). First, participants wrote down a feasible wish about getting to bed on time. Then they wrote down the most positive outcome of realising this wish as well as events and experiences related to that positive outcome. Then in a third step they had to envision a critical personal and internal obstacle standing in the way of attaining that wish, followed by an elaboration of the events and experiences they associated with it.[1] Finally, in a fourth step participants formed implementation intentions by answering two questions: 'When and where will the obstacle occur next?' and 'What can I do to overcome the obstacle?' They were then asked to link the two answers in terms of an if-then statement: If I encounter X, then I will perform Y! Last, participants were encouraged to practice this technique daily and to use it for any wish that they may have over the next 3 weeks.

### Information + positive thinking control condition

In the information + positive thinking control condition, participants received the same information, but also learned a positive thinking technique. First, participants wrote down and elaborated on the best outcome that would result from getting to bed on time. Then participants wrote and elaborated on another positive outcome resulting from getting to bed on time. Finally, participants formed an if-then statement constructed from the positive outcome and how participants would feel as a result of the

positive outcome (If positive outcome, then I will feel X!). Note, participants did not elaborate on a critical obstacle, nor did they form an implementation intention (if-then plan) on how to overcome it. Participants were nonetheless encouraged to use this technique, just as they were encouraged to engage in MCII in the other condition.

## Measures

We used a timeline follow-back approach to assess sleep procrastination, as well as a common-used self-report questionnaire. We also assessed participants' commitment to reduce bedtime procrastination and various background variables.

### Commitment to reduce bedtime procrastination

Before the intervention, directly after the intervention and 3 weeks later, participants indicated their commitment to go to bed on time (8 items; $\alpha = .78$; e.g. '*How committed are you to get to bed on time?*'; '*How motivated are you to reduce or stop your bedtime procrastination?*'), on a scale from 1 (*not at all*) to 7 (*very*). A scale score was created by taking the arithmetic mean of responses on all 8 items; higher scores indicated stronger commitment to reduce bedtime procrastination. Note that goal commitment is one determinant of successful goal pursuit and, as described above, commitment refers to how determined one is to reaching a particular goal (Locke, Latham, & Erez, 1988). Commitment as defined in previous research (Oettingen et al., 2009) is conducive to successful goal attainment, especially when goals are difficult to achieve (e.g. Klein, Wesson, Hollenbeck, & Alge, 1999), as is the cause with goals related to overcoming procrastination (e.g. Sirois, 2007).

### Bedtime procrastination discrepancy scores

To measure sleep schedules and bedtime procrastination, we used an adapted form of the timeline follow-back method (TLFB; Sobell & Sobell, 1992) targeting the past 7 days. Typically, the TLFB assesses retrospective daily estimates of various health behaviours including daily alcohol and cigarette consumption. As indicated by previous research (for a review see Hjorthøj, Hjorthøj, & Nordentoft, 2012), the TLFB is particularly well-suited for recalling critical health behaviours, thus making it ideal for measuring bedtime procrastination. The TLFB has been used extensively and shows psychometrically-sound properties even when administered online (Pedersen, Grow, Duncan, Neighbors, & Larimer, 2012). We opted to adapt this method to capture daily variability in participants' sleep schedules. Measurement of bedtime procrastination by the TLFB went as follows: for each of the past 7 days, participants retrospectively reported anticipated bedtime, actual bedtime and wake time. From these reports, we calculated two variables: sleep quantity and bedtime discrepancy. Sleep quantity was derived by simply calculating the time between actual bedtime and wake time, thus obtaining hours slept. To measure bedtime procrastination, we first calculated a discrepancy score for each day by subtracting actual bedtime from intended bedtime. Next, we averaged these 7 bedtime discrepancy scores to yield an average discrepancy score, such that higher scores equal more discrepant bedtimes on average. Bedtime procrastination is one of the two primary outcomes.

### Subjective bedtime procrastination

In addition to bedtime discrepancy scores, we also used an 9-item self-report scale developed to assess subjective bedtime procrastination (Kroese et al., 2014). This measure of bedtime procrastination is the most commonly used scale and the only measure validated to do so. Items were answered on 7-point scales ranging from 1 (never) to 7 (always) (e.g. 'I do not go to bed on time'); there was a satisfactory internal reliability at baseline ($\alpha = 0.82$) as well as 3 weeks later ($\alpha = 0.81$). Previous research has demonstrated this measure of bedtime procrastination to be a single-factor measure (Kroese et al., 2014). Subjective bedtime procrastination is an alternative measurement of our primary measure.

### Background variables

Participants also answered questions related to a number of background variables selected based on their relevance to sleep, procrastination, as well as motivation more generally. We assessed two variables inextricably linked to classic expectancy-value understandings of motivation and goal pursuit (e.g. McClelland, 1985; McClelland, Atkinson, Clark, & Lowell, 1953): *expectancies* and *incentive value*. Using methods recommended in prior research on the self-regulation of goal pursuit (Oettingen & Gollwitzer, 2010), *expectancies* were assessed at baseline using one item, *'How likely do you think it is that you will get to bed on time over the next 3 weeks?'* and a 7-point Likert scale (1, not at all likely; 7, extremely likely). Similarly, *incentive value* was measured using the item *'How important is it for you to get to bed on time over the next 3 weeks?'* and a 7-point Likert scale (1, not at all important; 7, extremely important). Importantly, we also assessed *general mental health* because it has been shown to exacerbate the disturbed sleep (Pilcher, Ginter, & Sadowsky, 1997), and *perceived stress* which also is known to be implicated in reduced sleep quality (Sadeh, Keinan, & Daon, 2004). Specifically, *general mental health* was assessed using a 4-item version of the patient health questionnaire (PHQ4). This four-item scale assesses transdiagnostic mental health over the past 2 weeks. Because this measure is frequently used in applied and healthcare settings (Goldberg et al., 1997), we used it to assess participants' mental health. Participants were asked to answer how often they have been bothered by a variety of problems using a 4-point scale ranging from 0 (*never*) to 3 (*always*) (e.g. '*Feeling nervous, anxious or on edge*' and '*Not being able to stop or control worrying*'). All four items were summed and higher scores indicated worse mental health ($\alpha = .82$). Finally, *perceived stress* was measured using the four-item PSS scale (Cohen, Kamarck, & Mermelstein, 1994). This scale probed self-reported levels of stress over the past 2 weeks. Items were answered on 4-point scales ranging from 0 (*never*) to 3 (*always*) (e.g. *'In the last month, how often have you felt that you were unable to control the important things in your life?'*). All four items were summed so that higher scores indicate more stress ($\alpha = .73$). At the end of the baseline survey, all participants filled out a battery of demographic variables—age, gender, race, marital status, household composition, number of children living at home, employment status and education level.

**Table 1.** Means and standard deviations for all Study 1 and Study 2 variables.

| | Study 1 | | Study 2 | |
|---|---|---|---|---|
| Variable | *M* | SD | *M* | SD |
| Goal commitment | | | | |
| Baseline | 3.51 | 1.40 | 4.18 | 1.19 |
| After intervention | 4.10 | 0.96 | 4.76 | 1.22 |
| Follow-up | 4.67 | 0.95 | 4.63 | 1.03 |
| S-R bedtime procrastination | | | | |
| Baseline | 5.08 | 1.02 | 5.10 | 0.97 |
| Follow-up | 4.80 | 0.96 | 3.52 | 0.90 |
| Bedtime discrepancy scores | | | | |
| Baseline | 103.05 | 73.36 | 68.39 | 69.10 |
| Follow-up | 78.98 | 82.99 | 76.09 | 59.70 |
| Sleep habits | | | | |
| Bedtime – baseline | 1:16 AM | 113 min | 1:02 AM | 103 min |
| Bedtime – follow-up | 1:12 AM | 123 min | 1:15 AM | 61 min |
| Waketime – baseline | 8:53 AM | 122 min | 9:04 AM | 94 min |
| Waketime – follow-up | 9:04 AM | 122 min | 9:01 AM | 63 min |
| Sleep duration – baseline | 7.62 h | 115 min | 8.02 h | 83 min |
| Sleep duration – follow-up | 7.84 h | 115 min | 7.77 h | 68 min |
| Expectancy | 3.77 | 1.52 | 3.19 | 1.47 |
| Incentive value | 4.79 | 1.37 | 4.85 | 1.30 |
| General mental health | 1.20 | 0.75 | 1.17 | 0.83 |
| Perceived stress | 2.95 | 0.71 | 2.89 | 0.70 |

Note. For Study 1, all follow-up means and standard deviations refer to TLFB scores collected 3 weeks later. For ease of comparison, in Study 2, all follow-up means and standard deviations refer to aggregated daily diary responses collected 1 week later. Refer to supplemental analyses for complete correlation matrices for both Study 1 and Study 2.

## *Sample characteristics and data analytic plan*

To estimate the intervention effect, we utilised mixed-model ANCOVAs where condition (information + MCII condition vs. information + positive thinking condition) was a between-person factor, time (baseline and 3-week follow-up) was a within-person factor, and baseline sleep quality, sleep quantity, anticipated bedtime, actual bedtime, as well as actual wake time were treated as covariates. Bedtime discrepancy at follow-up was the dependent variable (assessed in terms of the commitment to reduce bedtime procrastination bedtime, procrastination discrepancy scores and subjective bedtime procrastination). Because day-to-day variations in bedtimes were not of primary interest, we created aggregate scores for each week of TLFB responses in all analyses. If participants had missing responses for more than 2 days, they were removed from the analyses. Table 1 contains descriptive statistics for all primary variables of interest. All analyses were conducted using SPSS (version 25) and R-studio (version 3.6).

## *Attrition analyses*

As seen in Figure 1, attrition rate was acceptable for a study of this duration (Cugelman, Thelwall, & Dawes, 2011): out of the 510 participants initially recruited, 34 (6.6%) participants had incomplete data at baseline and 91 (17.8%) dropped out after 3 weeks. The final sample consisted of 383 participants (MCII = 193, positive thinking = 190). We assume that the missing data from our final sample were missing at random (MAR; Rubin, 1976). To assess potentially meaningful effects of our sample's attrition rate, we first evaluated whether participant dropout was dependent upon condition using a chi-square test, and we found that this was not the case, $\chi^2$ (1,

$N = 476$) = .16, $p$ =.69. We then compared retained and lost participants across a variety of baseline characteristics (e.g. demographics) and among the primary outcome measures (bedtime procrastination discrepancy scores, subjective bedtime procrastination and goal commitment). We found no significant differences for gender, $\chi^2$ (1, $N = 476$) = 3.24, $p$ = .36, race/ethnicity, $\chi^2$ (1, $N = 476$) = .96, $p$ =.33, general mental health, $t(473)$ = .76, $p$ = .45, perceived stress, $t(154.39)$ = .25, $p$ = .78, bedtime procrastination discrepancy scores, $t(472)$ = –.21, $p$ = .83, or subjective bedtime procrastination, $t(475)$ = .42, $p$ = .68, goal commitment, $t(484)$ = 1.32, $p$ = .19. However, we did find that participants who dropped out ($M = 3.33$, $SD = 1.72$) had significantly lower expectancies compared to those who remained in the study ($M = 3.77$, $SD = 1.52$), $t(484)$ = 2.46, $p$ = .01. Participants who dropped out ($M = 4.45$, $SD = 1.76$), compared to those who were retained ($M = 4.79$, $SD = 1.37$) also reported marginally lower incentive value, $t(126.37)$ = 1.74, $p$ = .09.

### *Randomisation check*

To check whether participants were successfully randomised, we compared baseline variables to see if our groups were equivalent across a variety of relevant characteristics. At baseline, participants in the MCII condition did not differ from participants in the positive thinking condition on expectancies, $t(383)$ = –.41, $p$ = .68, incentive value, $t(383)$ = –.39, $p$ = .70 or general mental health, $t(382)$ = .94, $p$ = .33. However, participants in the positive thinking condition ($M = 3.03$) reported significantly more perceived stress than those in the MCII condition ($M = 2.88$), $t(383)$ = 2.11, $p$ = .04. For the purposes of the present research, we report results for completers only.

## Results

### *Commitment to reducing bedtime procrastination*

We conducted a 3 (Time: before intervention vs. directly after intervention vs. 3 weeks later) × 2 (Intervention: MCII vs. positive thinking) mixed ANOVA on commitment to reduce bedtime procrastination, with the intervention entered as a between-subjects variable. As seen in Figure 2, commitment to reduce bedtime procrastination differed as a function of time, $F(2,758)$ = 49.41, $p < 0.001$, $\eta^2$ = 0.12. Specifically, Bonferroni-corrected *post-hoc* comparisons revealed a significant increase ($\Delta M = 0.55$) in commitment regardless of condition, directly following the intervention, $F(2, 758)$ = 49.41, $p < 0.001$, as well as a significant decrease ($\Delta M$ = –0.42) in commitment 3 weeks later, $F(1,379)$ = 3.08, $p < 0.001$. There was also a main effect of intervention type irrespective of time, whereby participants who performed MCII reported greater commitment to reduce bedtime procrastination ($M = 3.86$) compared to those who used positive thinking ($M = 3.67$), $F(1, 379)$ = 1.44, $p = 0.04$, $\eta^2$ = 0.011. Qualifying these main effects, we found the predicted time-by-intervention interaction, $F(2,758)$ = 4.14, $p = 0.02$, $\eta^2$ = 0.016. At baseline, participants did not differ in commitment by condition, $F(1,379)$ = .03, $p = 0.87$, but directly after the intervention, participants in the MCII condition reported greater commitment to reduce bedtime procrastination, $F(1,379)$ = 6.73, $p = 0.01$. Furthermore, after 3 weeks, participants in the MCII condition

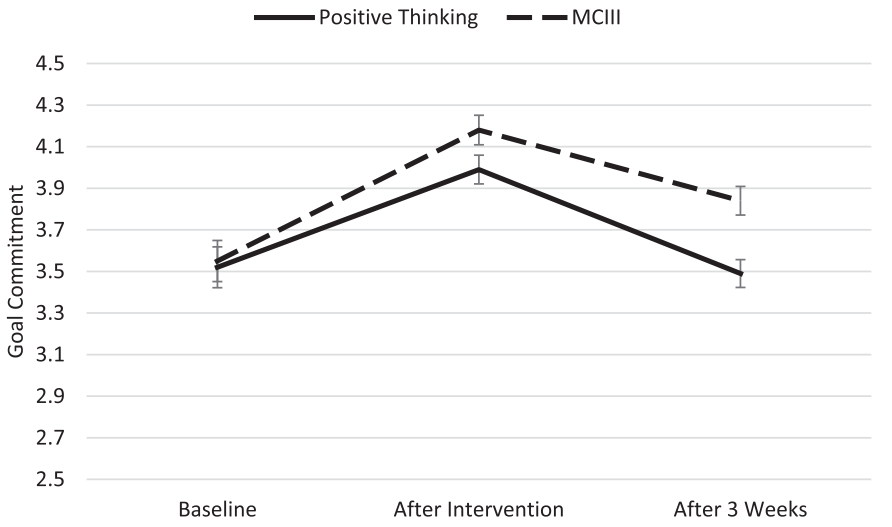


**Figure 2.** Goal commitment after intervention and after 3 weeks, by condition. *Note.* Error bars represent standard errors.

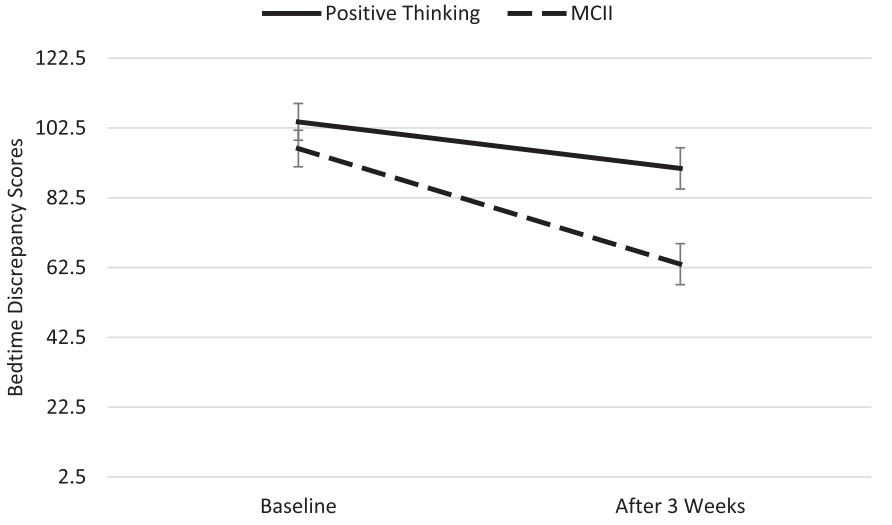


**Figure 3.** Timeline follow-back (TLFB) bedtime discrepancy scores, by condition. *Note.* Bedtime discrepancy scores are presented in average minutes per night. Error bars represent standard errors.

remained significantly more committed to reduce bedtime procrastination compared to participants in the positive thinking control condition, $F(1,379) = 13.45$, $p < 0.001$.

### *MCII Intervention effects on the two measures of bedtime procrastination*

We conducted a 2 (Time: before vs. after intervention) × 2 (Intervention: MCII vs. positive thinking) mixed ANOVA on bedtime discrepancy scores derived from the TLFB, where the intervention was a between-subjects variable.[2] There was a main effect of time, whereby bedtime discrepancies tended to be higher before the intervention ($M = 102.35$, $SD = 72.44$) compared to after ($M = 78.83$, $SD = 82.28$), $F(1,381) = 26.88$,

$p < 0.001$, $\eta^2 = 0.066$. There was also a main effect of intervention type, whereby participants who learned MCII ($M = 84.26$, $SD = 63.17$) reported smaller bedtime discrepancies than those who used positive thinking ($M = 96.92$, $SD = 63.01$), $F(1,381) = 3.84$, $p = 0.05$, $\eta^2 = 0.011$. Most importantly, we found the predicted time by intervention interaction, $F(1,381) = 4.31$, $p = 0.04$, $\eta^2 = 0.011$. As shown in Figure 3, although participants in both the MCII and positive thinking conditions displayed a reduction in bedtime discrepancy, this reduction was larger for people who learned MCII ($\Delta M = 32.94$) than for participants who used positive thinking ($\Delta M = 14.10$), $F(1,379) = 30.90$, $p = 0.001$. While there were no observed differences in bedtime discrepancies before the intervention, $F(1,379) = .69$, $p = 0.66$, we found a significant difference in bedtime discrepancies after the intervention, $F(1, 379) = 30.90$, $p = 0.01$.

Interestingly, this pattern of results was not present when using the nine-item subjective self-report measure of bedtime procrastination (Kroese et al., 2014). Following the same procedures as mentioned above, we found a similar main effect of time, whereby participants reported lower subjective bedtime procrastination after the intervention, $F(1,379) = 46.88$, $p < 0.001$, $\eta^2 = 0.11$. But, we did not find an effect of intervention type, $F(1,379) = 0.69$, $p = 0.41$, $\eta^2 = 0.002$ or an interaction effect, $F(1,379) = 0.12$, $p = 0.73$, $\eta^2 < 0.001$.

## Discussion

Study 1 utilised a critical motivation control condition. More specifically, we used a positive thinking control condition and ensured that all participants were given valuable information about the importance of getting enough sleep. Confirming our primary hypotheses, participants in the MCII condition (vs. the positive thinking control condition) indicated a reduced discrepancy between planned bedtime and actual bedtime 3 weeks after the intervention. Moreover, we found that MCII enhanced goal commitment directly after the intervention as well as 3 weeks later.

There are, however, a number of important questions left unresolved and some surprising results that merit further attention. Despite reducing discrepancy scores between planned bedtime and actual bedtime, participants did not actually get significantly more sleep, go to bed significantly earlier or wake up significantly later. Thus, it appears that the discrepancy reduction primarily emerged from individuals' revising their intended bedtimes. The fact that our participants did not sleep more or better is surprising. Apparently, participants in the MCII condition realised that their set bedtimes were unrealistic, thus leading them to revise planned bedtimes, rather than getting to bed earlier.

We used the TLFB in the present study. In and of itself, using this measurement tool is a novel contribution to the relevant literature. Moreover, our research suggests that this method may be helpful in detecting differences not picked up by more traditional self-report measures. Moreover, our operationalisation of bedtime discrepancy, unlike that of the more commonly-used bedtime procrastination measures which focus on subjective experience, quantifies procrastination in a readily interpretable and easily comparable metric—minutes of procrastination per night. While we found a positive effect of the MCII intervention using this metric, we did

not find respective evidence when assessing bedtime procrastination via the subjective self-report measure only. Possibly, the subjective self-report measure is more susceptible to demand characteristics and/or social desirability effects, while the TLFB measure is more robust and thus protected from such response biases; alternatively, the two measures may simply tap into different aspects of bedtime procrastination.

Finally, the design of Study 1 raises the question of whether the positive thinking control condition used might actually have had a negative effect on bedtime procrastination (meaning that MCII did not have a positive effect), as previous research suggests that positive fantasies are associated with less effort and reduced goal attainment (e.g. Oettingen & Mayer, 2002). In Study 2, we will therefore aim to have a more standard sleep intervention control condition, which will help to elucidate the directionality of the differences found in Study 1.

## Study 2

In Study 2, we aimed to compare the effects of MCII on reducing bedtime procrastination to a standard sleep intervention rather than a motivationally relevant control intervention. We also sought to validate our usage of the TLFB method of calculating bedtime discrepancy scores by conceptually replicating our results, again using a daily diary approach.

Similar to Study 1, all participants first received information about the importance of sleep sufficiency in order to decrease variance in knowledge differences (Brown, Buboltz, & Soper, 2002). Participants in the information + MCII group then also learned the same self-regulation technique as in Study 1—MCII. Participants in the information + sleep hygiene group were instead provided with twelve tips to achieve better sleep hygiene (Harvard Medical School Division of Sleep Medicine, 2007). We elected to use an information plus sleep hygiene control group because previous research suggests sleep hygiene to be among the best and most frequently-used tactics for improving sleep (Brown, Buboltz, & Soper, 2002). All participants were encouraged to use these strategies regularly and as often as they saw fit for the duration of the week-long diary study.

Consistent with Study 1, we hypothesised that MCII, relative to a sleep hygiene control condition, will (a) increase commitment to the goal of reducing bedtime procrastination and (b) lead to reduced bedtime procrastination. More specifically, with respect to goal commitment, we hypothesised an effect of intervention type (MCII vs. sleep hygiene) qualified by an interaction effect with time, such that participants will not differ at baseline, but those who use MCII will be more committed directly after the intervention, as well as after 1 week. Predictions for reduced bedtime procrastination are similar; we hypothesised a main effect for intervention type qualified by an interaction effect, such that participants will not differ in reported levels of bedtime procrastination at baseline, but participants who used MCII (compared to positive thinking control condition) will report reductions in bedtime procrastination after 1 week.

## Method

### Participants

We recruited students who wished to reduce their bedtime procrastination from the same large US university. Because we sought to conduct a diary study with repeated measures, we decided to collect data from a smaller sample as compared to Study 1. Given the complex nature of power analyses for multilevel designs (Lane & Hennes, 2018), we targeted a final sample size of 200 with a baseline collection period and seven daily diary reports. This sample size is consistent with sample sizes used in previous MCII diary-based intervention studies (e.g. Stadler et al., 2010). We used a similar recruitment procedure as in Study 1—college undergraduate participants were recruited via an online recruitment flier which simply stated: 'Do you stay up too late at night'? Our sample had 21 participants who were currently being treated for a sleep disorder or who worked a night shift; however, there were no observed differences in any of the baseline characteristics so they were retained in our final sample. Figure 1 presents a flow diagram of our recruitment, randomisation and experimental procedures.

### Procedure

The procedure in Study 2 was similar to Study 1, but with several key changes. As in Study 1, participants completed both the timeline follow back measure and the subjective self-report measure of bedtime procrastination (Kroese et al., 2014) at baseline. Next, participants read the same sleep information and were then randomly assigned to either an MCII condition or a sleep hygiene control condition using the same randomisation procedure as in Study 1. Both interventions were administered online and designed as parallel interventions in all aspects. However, participants in the information + sleep hygiene group learned about steps for improving sleep hygiene, whereas participants in the information + MCII group followed the same procedure as in the previous study. Participants began receiving daily emails directly following the baseline survey. The daily surveys comprised of measures about sleep habits and goal commitment from the day prior, every day for 7 days.

#### Information + MCII intervention condition

Instructions in the MCII condition consisted of two parts: an information portion where participants read a page of facts and statistics derived from CDC and the Mayo Clinic informational websites. The information on this page detailed the importance of sleep and the potentially harmful ramifications of insufficient sleep. Next, participants learned MCII following the same sequence used in Study 1. Participants were encouraged to practice this technique daily and to use it for any wish that they may have over the next week.

#### Information + sleep hygiene condition

In the information + sleep hygiene control condition, participants received the same information, but also learned about sleep hygiene strategies (Harvard Medical School

Division of Sleep Medicine, 2007). Participants were presented with twelve tips for improving sleep hygiene. This information was written for a general audience and included empirically-based information. Example tips include, 'Turn Your Bedroom into a Sleep-Inducing Environment' and 'Establish a Soothing Pre-Sleep Routine.' Moreover, participants could not advance the page until they had read all of the information. To ensure that the amount of time spent on the intervention was equivalent across groups, we matched the time required to complete this portion of the study across conditions. Participants were encouraged to act on the provided tips, just as they were encouraged to engage in MCII in the other condition.

## Measures

We assessed the same primary independent and dependent measures as in Study 1, with several notable differences pertaining to the follow-up measures. Instead of using an aggregate measure post-intervention like we did in Study 1, in Study 2 we used daily diary measures for all key outcomes.

### Baseline measures

To measure *Bedtime Discrepancy Scores* at baseline, we used the same 7-day TLFB (Sobell & Sobell, 1992) from Study 1. Scores were averaged together to obtain an overall value representing bedtime discrepancy scores for the previous week. To measure *Subjective Bedtime Procrastination* at baseline we created a score from the average of the same 8 items ($\alpha = .60$) from the self-report scale used in Study 1 (Kroese et al., 2014). To measure *Commitment to Reduce Bedtime Procrastination* participants indicated their commitment to go to bed on time (e.g. '*How committed are you to get to bed on time?*'; '*How motivated are you to reduce or stop your bedtime procrastination?*'), on a scale from 1 (*not at all*) to 7 (*very*) (Oettingen et al., 2009). A scale score was created from the average of four items ($\alpha_{\text{baseline}} = .84$; $\alpha_{\text{after intervention}} = .91$), whereby higher scores indicated stronger commitment to reduce bedtime procrastination.

### Diary measures

To asses *Bedtime Discrepancy Scores after Intervention*, every day we asked participants to report their planned bedtime, actual bedtime and wake time. From these reports, we calculated the same two variables as in the Study 1: sleep quantity and bedtime discrepancy. Sleep quantity was derived by calculating the time between actual bedtime and wake time. To measure bedtime procrastination, we calculated a discrepancy score by subtracting actual bedtime from intended bedtime, such that higher scores equal more discrepant bedtime. To measure *Daily Subjective Bedtime Procrastination* following intervention, we created a score from the average of the four momentary items from the self-report scale used in Study 1 (Kroese et al., 2014). To measure *Daily Commitment to Reduce Bedtime Procrastination*, participants indicated their commitment to go to bed on time (e.g. '*How committed are you to get to bed on time?*'; '*How motivated are you to reduce or stop your bedtime procrastination?*'). Instead of calculating averages aggregated across the week following intervention, we left all daily measures disaggregated in our analyses.

### Background variables

We again assessed several background variables as in Study 1. *Expectancies* were assessed at baseline using one item, *'How likely do you think it is that you will get to bed on time over the next 3 weeks?'* and a 7-point Likert scale (1, not at all likely; 7, extremely likely). Similarly, *incentive value* was measured using one item *'How important is it for you to get to bed on time over the next 3 weeks?'* and a 7-point likert scale (1, not at all important; 7, extremely important). *General mental health* was assessed using the 4-item version of patient health questionnaire (PHQ4; Goldberg et al., 1997). All items were summed and higher scores indicated worse mental health ($\alpha = .87$). Finally, *perceived stress* (Cohen et al., 1994) was measured using a summed score of the 4 item PSS scale ($\alpha = .66$). At the end of the baseline survey, participants filled out a battery of demographic variables—age, gender, race, marital status, household composition, number of children living at home, employment status and education level.

### Sample characteristics and data analysis plan

We set an *a priori* decision criterion regarding missingness: if participants had missing responses for more than either 2 days of recalled TLFB scores or daily bedtime discrepancy scores, they were removed from our analyses. Table 1 contains descriptive statistics for all primary variables of interest. As seen in Figure 1, the attrition rate was acceptable for a study of this duration (Cugelman et al., 2011): out of the 250 participants initially recruited, 27 (10.8%) participants had incomplete data at baseline and 43 (17.2%) dropped out during the daily diary portion. The final sample consisted of 178 participants with complete data (MCII = 88, sleep hygiene = 90). As in Study 1, we report results for completers only.

## Results

### Commitment to reduce bedtime procrastination

To estimate the intervention effect on commitment to reduce bedtime procrastination, we utilised a mixed-effects model that made use of all available data. This approach assumes that the missing data are MAR (Rubin, 1976). As seen in Figure 4, we estimated the effect of MCII (compared to a sleep hygiene control condition) on daily reports of commitment as measured. We estimated the fixed effects of condition (1 = MCII, 0 = sleep hygiene), day and their interaction, after adjusting for baseline commitment and commitment directly following intervention. Because sleep habits have been shown to vary considerably between weekdays and weekends (Lund, Reider, Whiting, & Prichard, 2010), we also added an indicator specifying the time of week (1 = weekend, 0 = weekday) into our model. Lastly, we specified a random intercept for participants.

We conceptually replicated the pattern of results found in Study 1. While baseline commitment unsurprisingly failed to predict daily commitment, $b = .07$, $se = .07$, $t(199.12) = 1.01$, $p = .33$, 95% CI[–.07, .22], commitment directly after the intervention significantly predicted daily reports of daily commitment, $b = .41$, $se = .07$, $t(195.82) = 5.79$, $p < .001$, 95% CI[.27, .55]. Intuitively we found that individuals were

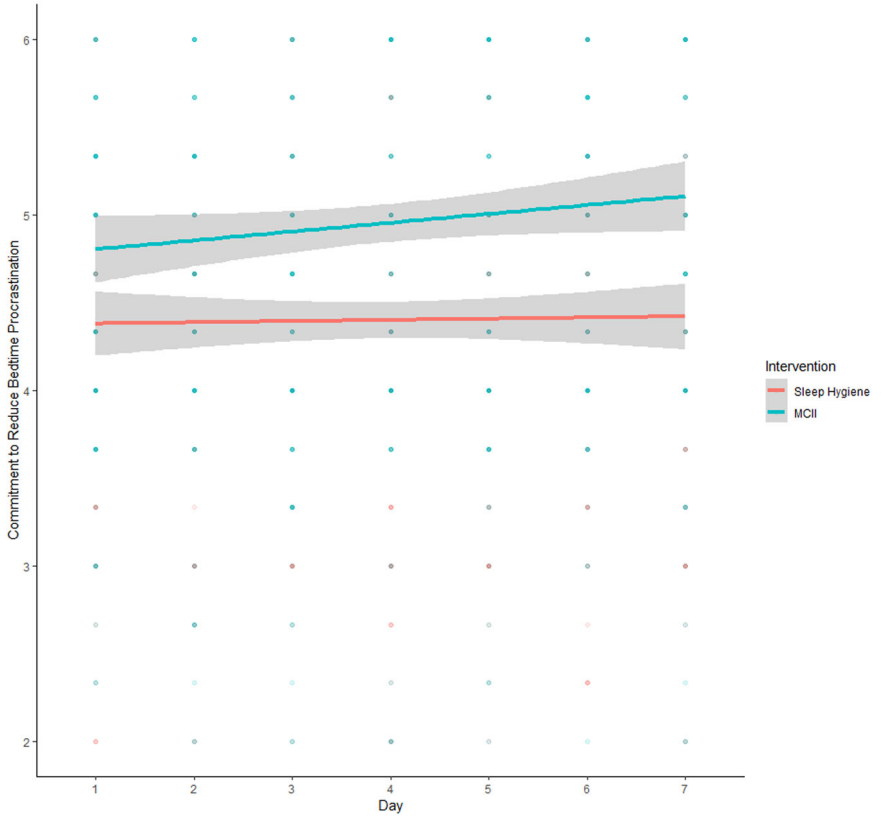


Figure 4. Commitment to reduce bedtime procrastination across 7 days, by condition.

significantly less committed to reduce bedtime procrastination on the weekend relative to a given weekday, $b = -0.23$, $se = .06$, $t(1065.58) = -3.71$, $p < .001$, 95% CI[–.35, –.11]. Regardless of intervention group, there was no effect of day after adjusting for baseline commitment, commitment after intervention and weekend, $b = .02$, $se = .02$, $t(1039.45) = 1.09$, $p = .27$, 95% CI[–.02, .06], suggesting that participants bedtime procrastination did not linearly change over the 7 days of diary reports. Conceptually replicating the pattern from Study 1, people in the MCII condition reported significantly greater commitment to reduce bedtime procrastination than those in the sleep hygiene condition, $b = .41$, $se = .16$, $t(606.99) = 2.61$, $p = .01$, 95% CI[.11, .72]. We found no interaction between intervention type and day after adjusting for baseline commitment, commitment after intervention and weekend, $b = .04$, $se = .03$, $t(1042.93) = 1.25$, $p = .21$, 95% CI[–.02, .09]. This suggests that the effect of the intervention on commitment did not change across the seven daily diary days.

### *MCII intervention effects on the two measures of bedtime procrastination*

To estimate the intervention effect on bedtime procrastination, we again utilised a mixed-effects model that made use of all available data. As seen in Figure 5, we estimated the effect of MCII (compared to a sleep hygiene control condition) on bedtime procrastination as measured by bedtime discrepancy scores.[3] We estimated the fixed

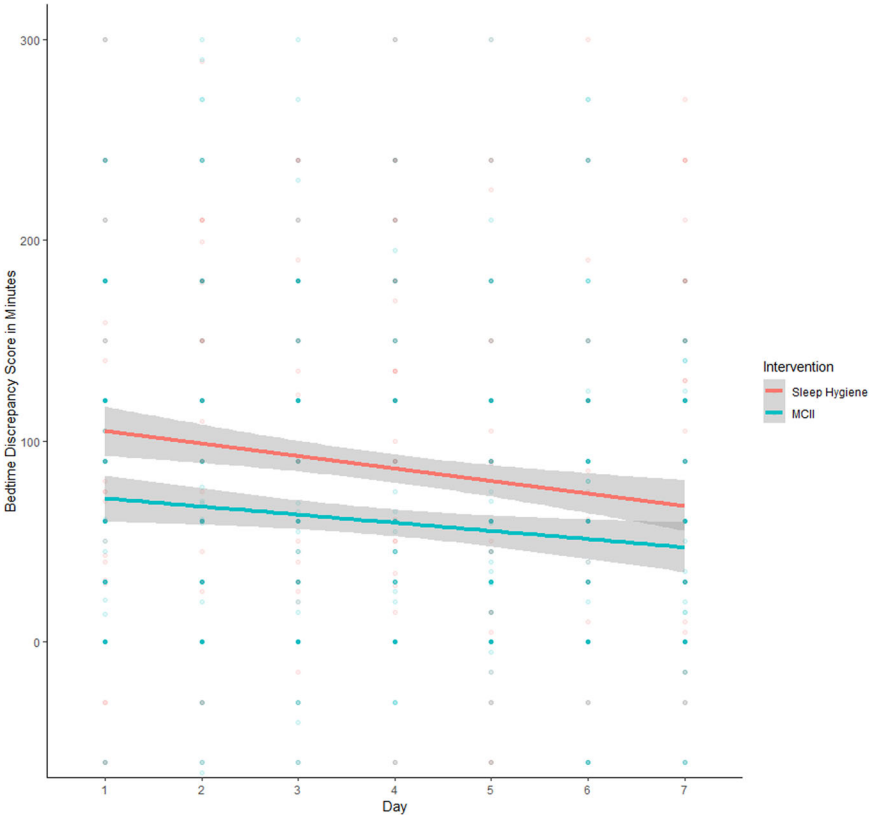


**Figure 5.** Daily diary bedtime discrepancy scores over 7 days, by condition.

effects of condition (1 = MCII, 0 = sleep hygiene), day and their interaction, after adjusting for baseline bedtime discrepancy scores as measured by the TLFB. We again added an indicator specifying the time of week (1 = weekend, 0 = weekday) into our model. Lastly, we specified a random intercept for participants.[4]

On a given weekday, a person in the sleep hygiene control condition with average baseline bedtime discrepancy scores is estimated to have an average of 96.00 min of bedtime discrepancy per night, $b = 96.00$, $se = 9.01$, $t(525.89) = 10.66$, $p < .001$, 95% CI[78.41, 113.58]. Importantly, the random intercept we fit suggests that there is meaningful variance in this intercept ($s^2 = 1989$). Baseline TLFB bedtime discrepancy scores predicted daily reports of bedtime discrepancy scores, $b = .22$, $se = .06$, $t(197.70) = 3.79$, $p < .001$, 95% CI[.11, .33].[5] As expected, irrespective of condition, individuals reported marginally significant increases bedtime discrepancy scores on the weekend relative to a given weekday, $b = 7.52$, $se = 4.75$, $t(1072.88) = 1.58$, $p = .11$, 95% CI[−1.80, 16.83]. Regardless of intervention group, we found an effect of day, $b = -6.51$, $se = 1.51$, $t(1030.80) = -4.30$, $p < .001$, 95% CI[−9.48, −3.55], suggesting that participants' bedtime procrastination linearly decreased across the 7 days of diary reports.

Conceptually replicating the pattern from Study 1, people in the MCII condition reported significantly lower bedtime discrepancy scores relative to those in the control condition, $b = -37.86$, $se = 11.23$, $t(695.40) = -3.37$, $p < .001$, 95% CI[−59.79, −15.92].

We did not observe an interaction between intervention type and day, after adjusting for weekend and baseline discrepancy scores, $b = 3.04$, $se = 2.14$, $t(1035.39) = 1.42$, $p = .16$, 95% CI[–1.15, 7.22]. This suggests that the effect of the intervention on bedtime discrepancy scores following intervention did not change across the seven daily diary days.

After constructing the same model as above—fixed effects for day, condition, an indicator for weekend, baseline subjective self-report of bedtime procrastination as a covariate and a random intercept for participant—using the subjective self-report of bedtime procrastination (Kroese et al., 2014)—we found (non)results in keeping with those observed in Study 1. Subjective self-reported bedtime procrastination at baseline was negatively associated with daily reports of self-reported bedtime procrastination, $b = –.33$, $se = .06$, $t(191.92) = –5.38$, $p < .001$, 95% CI[–.45, –.21]. We also found a marginally significant effect of weekend, whereby participants procrastinated less on the weekend, $b = –.13$, $se = .08$, $t(1098.04) = –1.54$, $p = .12$, 95% CI[–.28, .03]. We did find an effect of day, whereby each passing day was associated with significant decreases in subjective bedtime procrastination, $b = –.09$, $se = .03$, $t(1050.35) = –3.37$, $p < .001$, 95% CI[–.14, –.04]. Replicating the pattern Study 1, we did not find a significant difference in bedtime procrastination between the two intervention groups, $b = .14$, $se = .18$, $t(817.94) = .77$, $p = .44$, 95% CI[–.22, .50] or an interaction effect, $b = .04$, $se = .04$, $t(1056.07) = 1.21$, $p = .23$, 95% CI[–.03, .12].

## General discussion

Across two randomised trials, we found support for the effectiveness of an online application of MCII to reduce bedtime procrastination in students concerned about getting to bed on time. In Study 1, we found that MCII, relative to a positive thinking control condition, enhanced goal commitment directly after it was taught, as well as 3 weeks later. Of importance to our primary hypotheses, participants in the MCII condition, relative to the positive thinking condition, indicated a reduced discrepancy between the time when they wanted to go to bed and when they actually went to bed. In Study 2, we replicated these findings with a daily diary methodology and a sleep hygiene control condition.

Our study utilised one motivationally-relevant critical control condition (positive thinking) and one commonly-used health intervention (sleep hygiene). We ensured that all participants had the necessary information about the importance of getting enough sleep and we maintained tight experimental control. Thus, based on our findings, MCII appears to be an effective self-regulation tool for reducing bedtime procrastination. As prior research suggests, the content-independent nature of MCII allows for its effects to permeate other life domains (Johannessen, Oettingen, & Mayer, 2012); so participants may have used the MCII exercise in other life domains and reaped benefits there, as well.

Nonetheless, there are a number of important questions left unresolved. Despite reducing discrepancy between the time when participants wanted to go to bed and when they ended up going to bed, participants did not actually get more sleep, go to bed earlier or wake up later. Interestingly, it appears that the majority of this

discrepancy reduction emerged from individuals' revising their planned bedtimes. The fact that our participants did not sleep significantly more in both Study 1 and Study 2 is surprising. However, it appears that our participants may not have needed to sleep more, rather they may have only desired to get to bed on time. In both studies, our participants report sleep duration within the range of daily recommended sleep per night ($M_{Study\ 1} = 7.62$ h; $M_{Study\ 2} = 8.02$ h; Hirshkowitz et al., 2015), which suggests that although our participants reduced their bedtime procrastination, improving sleep duration might not have been a desired outcome for our participants. Given that our sample was comprised of students—a population that tends to possess a preference for eveningness (e.g. Digdon & Howell, 2008)—it is possible that the anticipated bedtimes were pushed to a later time because students realised they wanted to stay up later (rather than procrastinate less). It may also be that college students possess a schedule that can accommodate late bedtimes (and thus late wake times), whereas in a population of adults with inflexible work hours such plan revising would not be feasible. Thus, future research should accordingly analyse both people who adhere to strict working hours and people whose procrastination leads to reduced sleep duration.

We used the TLFB in Study 1, and a comparable daily diary measure in Study 2. Unlike the self-report measures of bedtime procrastination (Kroese et al., 2014, 2016) which focus on subjective experience, TLFB measures of bedtime discrepancy do quantify procrastination in a readily interpretable 'minutes per night' metric. While we found support for the effect of the MCII intervention when using a TLFB measure in Study1 and a comparable daily diary measure in Study 2, we did not find such evidence when assessing bedtime procrastination via a subjective self-report measure in either Study 1 or Study 2. Still, the assessment of participants' commitment to reduce bedtime procrastination did produce a pattern of results that was in line with that of the diary measures. The TLFB retrospection measure was found to be moderately correlated with the daily diary method, and thus may be a good proxy for bedtime procrastination when a daily diary approach is not feasible. However, additional research should continue to examine the strengths, downsides and differences of each of these measures of bedtime procrastination.

Although we used multiple methods for assessing bedtime procrastination—subjective self-report, TLFB, daily diary reports and commitment —all of our primary measures were based on self-report. Future research should examine the effectiveness of the MCII intervention when utilising objective measures, such as actigraphy. Nevertheless, this shortcoming should not be overstated as research examining differences in sleep measurement finds that self-report, diary and other subjective sleep measures each offer unique insights into sleep sufficiency. The unique contribution of each type of sleep measure emphasises the importance of using multiple indicators of sleep, as opposed to pursuing only external and thus potentially more objective measures of sleep (Bastien et al., 2003; McMakin & Alfano, 2015). In other words, while using objective measures of sleep will enhance the breadth of our understanding of bedtime procrastination, it will likely not undermine conclusions drawn from self-report measures. Moreover, future research should continue to examine the various ways in which more downstream health outcomes may be differentially predicted by

various reports of bedtime procrastination. It may be the case that bedtime discrepancy scores (via TLFB) predict different outcomes than either subjective self-report (via Kroese et al.'s measure) or objective measures of bedtime procrastination (via actigraphy).

Future work should also seek to discern the robustness of the observed MCII effects. The two studies we present here utilised time periods of 3 and 1 week, respectively; however, given prior research (e.g. Christiansen, Oettingen, Dahme, & Klinger, 2010; Stadler et al., 2009, 2010), it may be that treatment differences between MCII and control interventions may become *even more* pronounced over a longer period of time. Indeed, our findings are consistent with this interpretation given that we found a condition-by-time interaction in Study 1 (3 weeks), but not in Study 2 (1 week). Future research should aim to better understand the determinants and mechanisms related to bedtime procrastination. By enabling participants to specify outcomes and obstacles unique to their everyday lives, the content-independent nature of MCII allowed us to directly address the plurality of reasons for bedtime procrastination. While this did provide an elegant solution to the complex self-regulatory problems associated with bedtime procrastination, future work might want to delineate all of the possible as well as the most prominent elicitors of bedtime procrastination. For example, one might consider the importance of other self-regulatory issues (e.g. time management problems, resource allocation or goal conflicts) as drivers of bedtime procrastination. Future work with MCII may then seek to target those issues more directly. Moreover, as bedtime procrastination is facilitated by stressors encountered in daily life, it needs to be distinguished from 'winding down' before bed (Nauts et al., 2016; Reinecke & Hofmann, 2016). Respecting such a distinction would help to integrate multiple areas of research including sleep hygiene, procrastination and self-regulation more generally (e.g. Hagger, 2009).

Ultimately, the present research offers a first step towards a viable intervention with the potential to improve people's everyday lives in an easy and accessible manner. With the use of a novel measure of bedtime procrastination, this work advances current understandings of how bedtime procrastination can be regulated and provides a number of interesting research avenues at the nexus of sleep and self-regulation.

## Notes

1. Although participants in the MCII condition were asked to generate their personal, internal obstacles, it should be noted that prior research suggests individuals' self-regulatory efforts can be thwarted by a wide variety of obstacles. Prestwich Sheeran, Webb, & Gollwitzer (2015) detail a rich taxonomy of these obstacles. A key advantage of MCII is that participants are not asked to adopt a certain plan designed by the interventionist. Rather, by being prepared with MC, individuals are in a position to self-generate implementation intentions that best fit their personal obstacles.
2. Though not directly related to our primary aims, in Study 1 we also analysed the effect of time, intervention type, and their interaction on bedtime, waketime, and sleep duration. This information can be found in the supplemental material.
3. We also analysed the effect of time, intervention type, and their interaction on bedtime, waketime, and sleep duration. This information can be found in the supplemental material.

4. We also attempted to fit a model with a random effect for the slope of day. However, this random effect did not significantly improve model fit, suggesting that while individuals have different levels of bedtime discrepancy, there is no meaningful variance across participants bedtime discrepancy slopes over the seven diary days.
5. TLFB reports of sleep habits were, in general, strongly correlated with aggregated daily measures of sleep habits. Importantly, TLFB discrepancy scores were moderately correlated with the average daily discrepancy across 7 days, $r(156) = .31$, 95% CI[.16, .45]. Please refer to the supplemental information for a complete correlation matrix.

## Disclosure statement

No potential conflict of interest was reported by the authors.

## Funding

This study was not funded by any external mechanisms or cooperative agreements.

## Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

## Informed consent

Informed consent was obtained from all individual participants included in the study.

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## Data availability

The data that support the findings of this study are openly available at the Open Science Framework at osf.io/kx3yb.

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