Original Article

Sleep and interrogation: does losing sleep impact criminal history disclosure?

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Abstract

Study Objectives: Despite centuries of using sleep deprivation to interrogate, there is virtually no scientific evidence on how sleep shapes behavior within interrogation settings. To evaluate the impact of sleeplessness on participants' behavior during investigative interviews, an experimental study examined the impact of sleep restriction on disclosure of past illegal behavior.

Methods: Healthy participants from a university community ($N = 143$) either maintained or curbed their sleep (up to 4 h a night) across 2 days with sleep monitored via actigraphy. They were then asked to disclose past illegal acts and interviewed about them. Next, they were reinterviewed following an example of a detailed memory account (model statement). Disclosures were blindly coded for quantity and quality by two independent raters.

Results: Sleep-restricted individuals reported similar offenses, but less information during their disclosure with slightly less precision. Model statement increased disclosure but did not reduce the inhibiting impact of sleep loss. Mediation analysis confirmed the causal role of sleep as responsible for experimental differences in amount of information, and participants' reports suggested impaired motivation to recall information played a role.

Conclusions: The findings suggest that even moderate sleep loss can inhibit criminal disclosure during interviews, point to motivational factors as responsible, and suggest investigators should be cautious when interrogating sleepy participants.

Statement of Significance

Thousands of investigative interviews are conducted everyday by public safety, law-enforcement, and military organizations. Historically, sleep disruption has been used in these contexts as a tool to compel disclosure or confessions. Despite frequently imposed sleep disruption on detainees and commonly experienced sleep loss among interview participants such as victims or witnesses, there is no direct scientific evidence on how sleep shapes intelligence disclosures during investigative interviews. This experimental study evaluated how moderate self-imposed sleep-restriction impacted criminal history disclosure during a laboratory interview about past illegal acts, finding that sleep-deprived participants provided substantively less information with a trend for them to report less motivation to recall information. Asking for a second disclosure (following an example of the desired level of detail) increased the amount of information provided overall, but did not reduce the suppressive impact of sleep. The findings carry direct implications for science and practice of investigative interviewing and point to the importance of sleep for long-term memory retrieval.

Introduction

Historical and journalistic accounts reveal persistent and on-going use of sleep deprivation as a means of "breaking the resistance" of uncooperative interrogation participants [1]. Khalid Sheikh Mohammed (KSM), who planned the 2001 attacks on the United States, was detained and subjected to 132 h of continuous sleep deprivation [2]. Even when not imposed on detainees, sleep disruption is endemic to custodial environments across military and law-enforcement sectors [3]. Sleep disruption is also inevitable among various participants of investigative interviews, as police often interview suspects, victims, and witnesses at night or following traumatic events that disrupt sleep [4, 5]. As a result, a significant number of investigative interviews are certain to involve sleep-deprived participants.

The lengthy interrogations themselves can produce sleep disruption, and may be intentionally aimed at wearing down suspects. A survey of more than 600 law-enforcement investigators indicated their longest interrogation to last 5 h, on average, ranging up to 72 h [4]. Inducing tiredness alongside other types of discomfort is common to accusatorial interview approaches frequently taught to investigators, which contributes to lengthy interviews [6–8]. Military investigators have also reported intentional deprivation of sleep among detainees in service of ensuring compliance [9].

The prevalence of sleep deprivation as a tactic to obtain information is based on the premise that disrupting sleep will ultimately increase the amount of accurate and useful information that a participant is otherwise unwilling to provide [10]. While sleep deprivation has also been involved in coercive approaches aimed to ensure compliance or force confessions [8, 9], the key question for investigators and those collecting human intelligence involves efficacy of the tactic and the value of the information obtained. Although there is little direct scientific evidence regarding these assumptions, behavioral evidence that bears on this question suggests that sleep-deprived interview participants should be less likely to provide reliable human intelligence. First, sleep-deprived interview participants may be more *cognitively impaired*, with problems in sustaining attention on the task at hand, recalling relevant information, or understanding situational demands [11–13]. Second, sleep-deprived participants may be more *socially withdrawn*, namely less attentive to social cues, less motivated to meet interview demands, and more socially avoidant or disfluent [14–16]. Finally, sleep-deprived interview participants may be more *emotionally distressed*, with increased stress responses, anxiety, anger, fatigue, and behavioral unpredictability [17–19]. These observations are inconsistent with the premise that sleep deprivation helps increase (accurate) disclosure, even if participants show apparent behavioral compliance with interrogators (e.g. falsely confess) [20].

In this vein, research targeting the role of sleep in investigative settings suggests that after about 2 days without sleep, individuals can become more vulnerable to leading questions, more likely to change their answers when contradicted, and show more confidence in false memories [21–23]. To examine confessions, one experiment compared students who were typically rested to those who stayed up all night in their willingness to sign a (false) statement acknowledging they broke an important rule of the study (all were innocent)—50% of sleep-deprived individuals signed a false statement on the first request, compared with only 18% of their better-rested counterparts [24]. Another investigation examined circadian factors, finding that individuals were more likely to admit to wrongdoing when time of the day was mismatched with their chronotype, such that evening-oriented individuals confessed to more offenses in the morning than at night, while morning-oriented individuals admitted to more offenses at night than in the morning [25]. These findings suggest that total sleep deprivation (24 h or more) or circadian misalignment could render individuals more responsive to social pressures, namely susceptible to social contamination of memory and false confessions. In support of this conclusion, a recent analysis of 600 Palestinian ex-detainees revealed that those who reported significant sleep deprivation during detention produced a higher number of confessions with either true or false statements, questioning the efficacy of sleep loss in extracting the truth. Moreover, the higher number of confessions did not result in more convictions or longer prison sentences, further questioning the utility of sleep loss as means to ensure prosecution [3].

However, this evidence does not address whether the *amount* and *detail* of information individuals are likely to provide during investigative interviews is affected by sleep loss. Instead of confessions, most investigative interviews seek to obtain information or intelligence that is detailed, relevant, and can be corroborated. In words of one military investigator, "If the bad guy does not want to admit he is bad but wants to share reliable information in order to try and convince me he is a good guy, then it would be foolish of me to focus on his guilt" [9]. In everyday law-enforcement contexts, investigative interviews frequently involve reluctant witnesses, embarrassed victims, and confidential informants, where the goal is always obtaining information instead of a confession. Even cooperative interviews can involve lost sleep, and losing information in such cases can exert a significant influence on investigations. Regardless of its veracity, obtaining more intelligence (i.e. details and names) is also critical to evaluating credibility of information provided by interview participants as well as detecting deception [1]. For example, it is easier to spot a false alibi when accounts provided by individuals need to include a lot of detail and context, because liars usually produce fewer details [26].

Finally, it is not clear whether more common, real-world doses of sleep loss impact disclosure and behavior during investigative interviews. Because *total* sleep deprivation has been the exclusive focus of the few experimental studies addressing interrogation behavior, to what extent those effects carry over to the more commonly experienced *partial* sleep restriction is unknown. Given most interviews occur with participants who have had at least some sleep, it is critical to examine the impact of more ecologically valid levels of sleep loss.

Study Purpose

The purpose of the present experiment was thus to examine the causal impact of sleep restriction on the disclosure of past criminal behavior within an interview setting. To our knowledge, this is the first experiment to examine the impact of sleep loss on gathering human intelligence about past crimes. To this end, it tested the impact of at-home sleep restriction among 143 members of a university community on the quantity and quality of information disclosed

during a criminal history interview with an experimenter. While the participants did not face legal risk, they nevertheless discussed embarrassing or guilt-inducing illegal behaviors—important obstacles to disclosure among actual victims, witnesses, and suspects. Following their initial disclosure, interview participants also listened to a "model statement," a detailed memory account of an unrelated event known to increase information yield [27]. Participants then provided information about this event again. As mentioned earlier, eliciting more details during an interview is critical both for amassing facts as well as for distinguishing deceptive from honest accounts. In this case, a model statement intervention was used as it might reduce any deleterious influence of sleep restriction, namely differences in information yield due to sleep loss could be ameliorated following exposure to a detailed model statement. Alternatively, sleep loss could exert a more pervasive effect, affecting the amount of information similarly across initial and post-model-statement disclosures.

To evaluate intelligence yield from interview participants, blind raters listened to audio recordings, counted actionable pieces of intelligence (who, what, where, when, why, and how), and rated their level of quality (detail and precision). Moreover, participants self-reported on a variety of interview experiences. Our primary hypothesis was that sleep-restricted individuals would disclose *less* information than their more rested counterparts, given that even moderate sleep loss increases cognitive impairment, social withdrawal, and emotional distress, reactions likely to interfere with efficacious interviewing and provision of human intelligence [11–19]. Note that all interviews focused on events that occurred prior to the study; hence, any effects of sleep restriction can only be attributed to how people recall or report episodic memories, and not how well they encoded or consolidated such memories. While there was no access to ground truth, random assignment eliminated any confounds with motivated distortion or preexisting memory differences across conditions. Finally, any effect of the model statement on disclosure can only be attributed to motivational or practice factors, as cognitive competency (e.g. working memory) should not be affected by a simple instruction to repeat retrieval. As a result, should the model statement qualify the impact of sleep restriction on disclosure (e.g. compensate for the hypothesized lower disclosure), motivational rather than competency processes would be implicated.

Methods

Participants

Due to lack of prior research to suggest effect size, we aimed to capture at least a moderate effect of $d = 0.42$, the average effect size in experimental behavioral research (from a meta-analysis of 177 randomly selected experiments) [28]. A power analysis using G*Power 3.1 for a two-tailed *t*-test suggested 140 participants would be sufficient to ensure 0.80 power for detecting this difference. Furthermore, for a two-factor mixed design targeting a within-between-subjects interaction with 160 participants would be sufficient to ensure 0.80 power for detecting even a small interaction effect approximating $d = 0.20$, assuming 0.60 correlation between repeated observations and 0.05 level of significance [29]. Findings are interpreted with a focus on effect sizes, confidence intervals, and practical differences, rather than arbitrary *p*-value thresholds for rejecting implausible null hypotheses [30].

A total of 143 participants from a large Midwestern university and the surrounding community were recruited to participate in a study on "sleep restriction and interviewing in healthy adults." They were randomly assigned (using a randomly generated list of two values each representing one condition) to 2 × 2 mixed design with sleep restriction manipulated between-subjects, and a within-subject manipulation where a free recall interview was followed by introduction of the model statement and a second recall attempt. Prior to participating in the study, all interested parties were screened over the telephone. To minimize risks from participating in the study, individuals who self-reported a diagnosis of (1) sleep, mental, or a physical illness, (2) overnight work, or (3) sleeping less than 6 h a night on average were *not* invited to participate. All participants provided signed informed consent which informed them that any disclosures will be confidential and will not result in legal risk. The sample was 63% male, had an average age of 21.81 (*SD* = 4.16, range 18–69), and 71% of participants identified as white. All research procedures were approved both by the Iowa State University Office for Responsible Research and the Federal Bureau of Investigation's Internal Review Board, with research conducted according to relevant guidelines and regulations. The analyses were not formally preregistered. Relevant research materials, coding instructions, stimuli, and de-identified data can be found on https://osf.io/yqa4f/.

Procedures and measures

Participants came to the lab twice. During their initial session, they signed informed consents, were randomly assigned to a *sleep-restricted* or a *control* condition, and then completed several survey measures on personality and typical sleep patterns, as well as several unrelated computer tasks (either an emotion suppression task or an empathy task that required identifying basic emotions, subjects of separate research inquires). These measures were delivered via the Qualtrics Survey platform; they lasted around 30 min and are not discussed further.

Based on random assignment, the experimenter then created a "target" sleep schedule for each participant. If the participant was in the *control* condition, the experimenter instructed the participant to adhere to their expected sleep and wake times for those particular days. First, we asked each participant to report their expected bedtime and rise time for the next 2 days. If the participant was in the *sleep-restriction* condition, the experimenter provided a new target sleep time 2 h later than originally expected by the participant, as well as a new wake time 2 h earlier than originally expected by the participant. Participants in the sleep-restricted condition were instructed to adhere to these new sleep and wake times as best they could and to avoid naps, alcohol, caffeine, or psychoactive drugs. This procedure encouraged participants to remove up to 8 h from their typical sleep across 2 days and has been found effective in prior research [18]. To help participants wake up at their designated wake times, they received an automated phone call at their scheduled wake-up time. Participants were compensated with $50, and better adherence to the assigned sleep–wakes schedule yielded compliance bonuses ($5 for each hour awake assigned between 10:00 pm and 6:00 am).

After establishing their schedule with the experimenter, participants received the Actiwatch Spectrum Pro (by Phillips Respironics), which they wore on their nondominant wrist until their return to the laboratory. This device recorded movement at 30 s epochs to estimate sleep–wake state. Although sleep–wake state as recorded by the Actiwatch highly converges with polysomnographic recordings, all recordings were visually inspected by the second author to increase accuracy [31]. If necessary, sleep–wake recordings were manually adjusted on the basis of participant-entered sleep and wake times (using Actiwatch buttons), alongside recorded light or movement (by the second author) [32]. Daytime naps were not included in sleep calculations, but were extremely rare. Actiwatch data on sleep duration served as a manipulation check and were used as an intervening factor in a causal mediation analysis.

Criminal history disclosure

Following the two nights at home, participants returned to the laboratory and returned the Actiwatch. Using an established paradigm [33], participants were then given an opportunity to disclose and discuss past illegal behaviors. First, individuals were escorted to a private room and provided with a sheet of paper (without their name) that listed 20 criminal behaviors in roughly ascending order of legal severity (ranging from transporting fireworks and trespassing, to shoplifting and driving under the influence; see [34] and Supplemental Online Materials). They were asked to indicate whether they had engaged in each of these by checking "yes" or "no." The experimenter then obtained the information sheet from the participants and initiated a brief investigative interview.

The interview room was of moderate size, and involved both the experimenter and a camera facing the participants across a larger table. The experimenter then assured the participant of confidentiality and asked the participant to recall a specific time that they committed the most severe crime they disclosed (the highest number the participant checked on the sheet), asking "would you be willing to talk to me about that time?" If the participants declined (or did not admit to any illegal behaviors on the list), they were asked if they were willing to discuss a time when they wronged someone (even if not breaking the law).

If the participant agreed, they were asked to describe "a specific instance when you did this behavior" and then "to provide as many details as you can remember about the event." Participants then described this event to the experimenter while being video recorded (though only audio was stored and used for coding purposes). All experimenters were female (with the exception of one session), wore white lab coats throughout the session, and were trained to read from a script during the interview procedures while maintaining a neutral, yet serious, demeanor.

After providing their initial disclosure of the event, participants were told that prior research has shown that providing a model of the level of detail required was helpful to interviewees. They were then asked to listen to a "model statement," an audio recording of a man recounting his experience at the Iowa State Fair in prodigious detail (adapted from [27]). Participants were then prompted to recount their story *again*, with a focus on providing a higher level of detail as illustrated by the model statement they just heard. No additional prompts were used.

Audio recordings were edited to create separate sets of (1) initial disclosures and (2) post-model-statement disclosures. These two sets of recordings were provided to two raters not previously involved in the study and blind to experimental conditions as well as hypotheses. Each rater coded all of the disclosures in a random order on both quantity and quality of information (per [33]). To capture the *quantity* of information, each rater counted the number of verifiable details (potentially falsifiable by independent evidence) obtained during the disclosure, namely who, what, where, when, why, and how (thus ranging 0–6). Even if multiple people or locations may have been involved, specifying only one of the relevant elements was sufficient to count the presence of the detail. To capture *quality* of information, raters evaluated the precision of each detail by assigning values between 1 (not explicit and have to infer) and 3 (additional context or specificity). For example, for time of the event ("when"), raters indicated whether only season or time of day was reported (1), month or hour was reported (2), or the exact date and time were reported (3). Failing to report a detail automatically resulted in a score of "0." Inter-rater agreement was evaluated for both quantity and quality of information by calculating agreement correlations across both raters' sets of judgments (number and precision of details provided, respectively) separately for those taken before and after the model statement. Overall agreement rates for the number of details provided averaged 89.2% (ranging from 77.2% to 98.7%). The rated number of details provided by the two independent raters correlated 0.71 and 0.70 across the initial and model statement disclosures, respectively. The level of precision correlated between 0.47 and 0.74 across various six details for initial disclosures, and between 0.43 and 0.66 for repeat disclosures. There was thus acceptable to strong agreement between the raters in distinguishing one event account from another [35]. The precision of "what" and "how," arguably the most complex details, yielded the least agreement. Because independent sets of raters evaluated pre- and post-model statement accounts, it was not possible to evaluate the number of novel details provided the second time.

Interview reactions

Following the recorded interview, participants completed computerized survey measures regarding their interview experience. These included (1) perceived treatment by the interviewer (e.g. professionalism), (2) impressions of the interviewer (e.g. likability), (3) participants' level of cooperation (e.g. how much they disclosed and how much they resisted), (4) motivation and effort when disclosing information, (5) meta-cognition regarding the event (e.g. how strong they felt their memory of the event was, did they recall verbatim or gist content), and (6) emotions about the event (e.g. guilt). All items were rated on 7-point Likert-type scales (see Supplemental Online Materials for exact wording of all items). Participants also indicated their perceived disclosure, by reporting "How much information do you think you provided to the interviewer," rated on a 1 (None at all) to 7 (A lot) Likert-type scale. Finally, participants were then debriefed, offered transportation, and paid for their participation.

Results

Data exclusions and manipulation checks

Data were first inspected for completeness. Across all participants, 8 were removed because they did not disclose any illegal or antisocial behavior to be interviewed about, and 17 additional participants were removed because the interview recording was not available due to equipment failure, refusal to discuss the event, or unexpected errors (e.g. discussing an event different from one reported on the checklist or lack of condition information in one case). This resulted in the final sample size of 118 participants (58 in restricted and 60 in the control condition, with 11 and 12 participants removed from each condition, respectively, but note 4 with no condition data). Note a slightly higher number for analyses involving self-reported data not contingent on video recordings or lower for analyses involving model statement disclosures. All remaining participants were included in the experimental analyses regardless of their (varying) compliance with the sleep schedule, as to minimize data loss and avoid endogenous selection biases in estimates of experimental effects [36].

Sleep restriction effectiveness

Examination of actigraphic recordings indicated that participants in the control condition slept an average of 422 and 406 min on the first and second nights, respectively, whereas those who restricted slept an average of 269 and 292 min on the first and second nights, respectively. This yielded an average nightly sleep duration of 6.9 h for the control condition (4.4–10.2 h), and 4.6 h (2.4–7.8 h) for the restriction condition, an overall difference of 4.4 h, $t(118) = -10.18$, $p < 0.001$, 95% CI (−317, −214 min), $d = -1.87$. In brief, the average sleep-restricted participants lost little more than half a night of sleep across the 2 days of the study. As would be expected given increased sleep pressure among the restricted participants, they also took fewer minutes to fall asleep (Sleep Onset Latency, $M = 15.1$; $SD = 14.8$) than did control participants ($M = 24.0$; $SD = 20.2$), $t(113) = -2.67$, $p = 0.009$, $d = 0.50$. Sleep-restricted participants spent slightly fewer minutes awake after sleep onset (wake after sleep onset, $M = 30.4$; $SD = 34.3$) than did control participants ($M = 45.1$; $SD = 45.8$), $t(113) = -1.93$, $p = 0.055$, $d = 0.36$.

Finally, there were no systematic difference in timings of interview sessions, with the average timing of interviews for the restricted participants at 12:40 pm ($SD = 2:30$ h) and for control participants at 1:13 pm ($SD = 2:11$ h), $t(115) = -1.27$, $p = 0.207$. Sessions occurred between 8:30 am and 5:00 pm.

Types of disclosed offenses

Absolute frequencies of specific offenses selected for interviews (reported across experimental conditions) appear in Figure 1. Sixteen out of 20 listed offenses were selected for interviews at least once. Using alcohol before 21 years old (#4), experimenting with illegal drugs (#11), and driving under the influence (#19) were the most common. Overall, the patterns of criminal history disclosure were nearly identical across the conditions and typical for the sampled population (young adults).
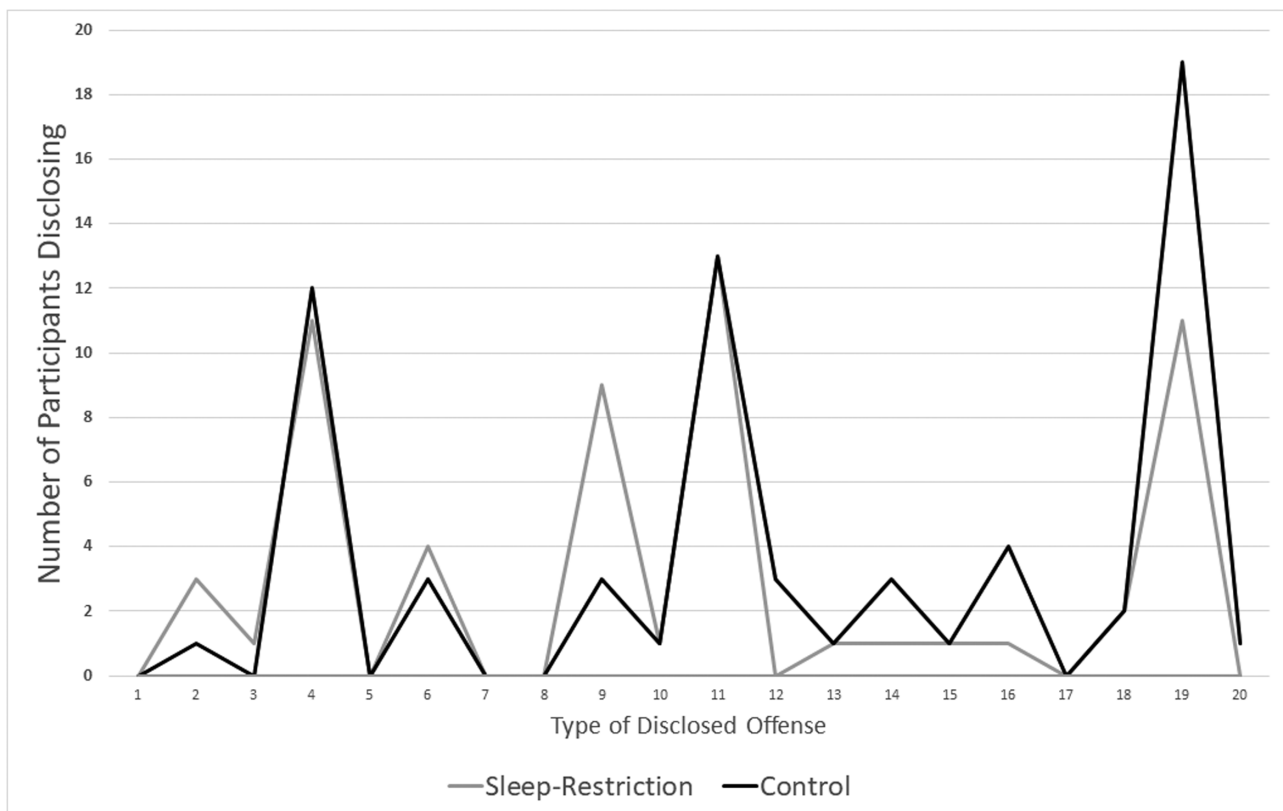

Figure 1. Distribution of interview-targeted offenses as a function of sleep-restriction.

The impact of sleep restriction on disclosure

To examine differences in information yield as a function of sleep restriction and the model statement, raters' aggregated scores for *quantity* of information (the number of details disclosed) and *quality* of information (averaged ratings of precision) were each submitted to a 2 (sleep-restriction, manipulated between-subjects) by 2 (model-statement, manipulated within-subjects) mixed ANOVA. The results appear in Figure 2, while descriptive statistics and correlations between the key measured variables appear in Table 1.

Compared to the *number of details* disclosed by participants who followed their typical sleep schedule ($M = 5.00$ details, $SD = 1.04$), sleep-restricted participants disclosed fewer details on average ($M = 4.67$ details, $SD = 1.04$), $F (1, 109) = 4.49$, $p = 0.036$, $d = 0.32$, 95% CI [–0.63, 0.11]. In an absolute sense, sleep-restricted participants provided 7% less information (across both disclosures) than their more rested counterparts. Participants also disclosed more information following the model statement ($M = 5.18$; $SD = 0.91$) than before ($M = 4.50$; $SD = 1.04$), $F (1, 109) = 40.97$, $p < 0.001$, $d = 0.70$, 95% CI [–0.97, –0.42]. In an absolute sense, participants provided 15% more information following the model statement than during their initial disclosure. There was little evidence that administering the model statement moderated the impact of sleep restriction, $F_{interaction} (1, 109) = 0.341$, $p = 0.561$. As evident by individual means, the impact of sleep restriction on information quantity was only slightly higher before the model statement (7% less information) than after it (5% less information). Overall, these differences have clear practical significance. If an investigator interviewed 10 people who lost a similar amount of sleep as participants in this study (relative to 10 more rested people), she could expect 3 fewer pieces of critical information about the case in terms of who, where, when, what, why, or how the crime was committed. Similarly, a repeated disclosure following a clearer standard of desired detail (i.e. the model statement) could lead to six or more pieces of information relative to the original disclosure (regardless of sleep restriction). To explore whether particular pieces of information may be more affected, we evaluated frequency of given types of detail across the conditions. These nonparametric tests (not corrected for multiple comparisons) suggested sleep-restricted individuals reported fewer "when" details in their original disclosures ($p = 0.053$) and fewer "where" details in the second disclosures ($p = 0.029$, complete results appear in the Supplementary Materials).

Compared to *precision* of information disclosed by participants who followed their typical sleep schedule ($M = 1.37$, $SD = 0.33$), sleep-restricted participants did not provide substantially less precise information, on average ($M = 1.31$, $SD = 0.38$), $F (1, 109) = 1.00$, $p = 0.32$, $d = 0.17$, 95% CI [–0.59, 0.17]. Participants disclosed appreciably more precise information following the model statement ($M = 1.48$; $SD = 0.40$) than before ($M = 1.21$; $SD = 0.31$), $F (1, 109) = 58.85$, $p < 0.001$, $d = 0.77$, 95% CI [–1.0, –0.46]. As with quantity of information, there was little evidence that the model statement qualified any impact of sleep restriction, $F_{interaction} (1, 109) = 0.119$, $p = 0.730$. When contrasted with the effect on the number of details, the precision of those details was thus less sensitive to sleep restriction, but slightly more sensitive to repeated disclosure following the model statement.

In contrast, when asked for their own *subjective* assessment of how much information they provided to the interviewer overall, sleep-restricted participants tended to report providing slightly *more* information ($M = 5.41$, $SD = 1.17$), than those in the control condition ($M = 5.12$, $SD = 1.17$), $t (116) = 1.38$, $p = 0.17$, $d = 0.25$, 95% CI (–0.13, 0.72), although this difference did not reach significance. At the same time, there was some evidence that participants invested less effort during their disclosure, with tendencies to report less motivation to remember ($d = 0.35$, $p = 0.06$) and more effort needed to remember the event ($d = –0.29$, $p = 0.12$). Taken together, while not reaching conventional standards of statistical significance, the similar differences across several queries suggest that sleep loss may have hampered the motivation to remember actual details or made it more difficult, which may have contributed to less disclosure. In this vein, participants' reports of impaired motivation and effortfulness did exhibit correlations both with sleep duration and quality of details disclosed in the hypothesized directions (see Supplemental Online Materials for all differences in self-reports and associated confidence intervals).

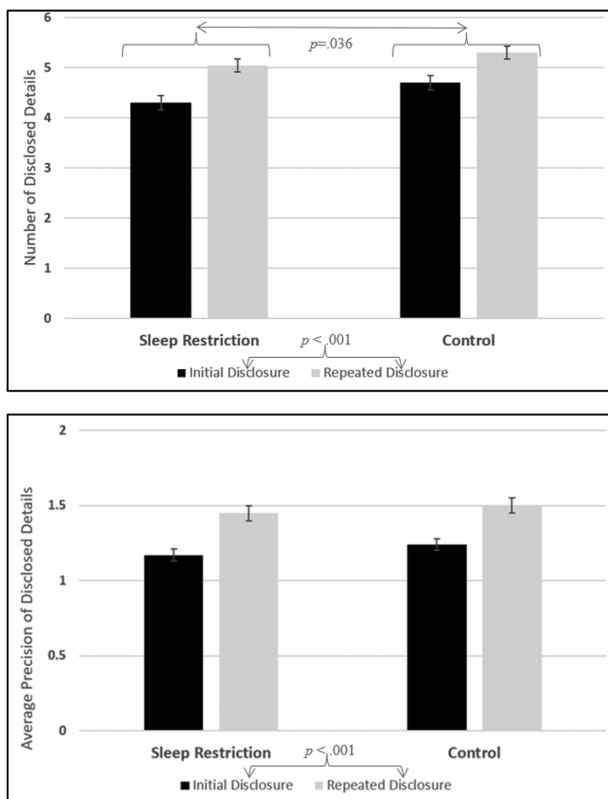**Figure 2.** Quantity (top) and quality (bottom) of disclosed information as function of sleep restriction and the model statement instructions.

Sleep duration as a causal mediator of experimental effects on disclosure

To directly examine whether sleep duration was responsible for the observed experimental differences in quantity of disclosure, we tested a causal mediational chain with experimental condition as the independent variable, actigraphically recorded sleep duration as the mediating variable, and quantity of information during the initial disclosure as the dependent variable (using PROCESS v.3 MACRO for SPSS that utilizes 5000 bootstrap samples) [37]. The results of this analysis appear in Figure 3 and

Table 1. Correlations and descriptive statistics for all dependent variables

	1.	2.	3.	4.	5.	M	SD
1. Sleep duration	–					690m	187m
2. Initial details	0.24*	–				4.5	1.0
3. Model-statement details	0.11	0.35***	–			5.2	0.92
4. Initial precision	0.16	0.72***	0.36***	–		1.2	0.33
5. Model-statement precision	0.04	0.27**	0.77***	0.47***	–	1.5	0.40
6. Subjective disclosure	–0.13	0.26**	0.08	0.26**	0.10	5.3	1.2

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$. $N = 106–119$.

Indirect Effect = **.43** (95% CI: .09, .78)
Total Effect = **.24** (95% CI: .09, .40)
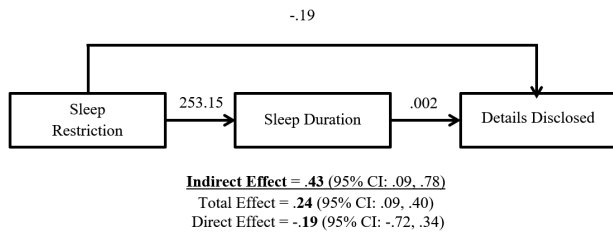Direct Effect = -**.19** (95% CI: -.72, .34)

Figure 3. Sleep duration as a causal mediator of the impact of sleep-restriction on the number of details initially disclosed.

indicate a singular role of sleep duration in explaining the experimental effect of sleep restriction on the initial number of details ($R^2 = 0.07$, $p = 0.03$). Specifically, there was no significant direct effect on disclosure but only a substantial indirect effect, with sleep duration mediating the impact of experimental manipulation on the number of details reported, IE = 0.43, 95% CI (0.09, 0.78). This provides strong evidence that restricted sleep, rather than reactions to the sleep-restriction protocol independent of lost sleep (e.g. frustration about changing daily routine), is responsible for inhibited disclosure during investigative interviews the next day.

Discussion

These findings are the first to address whether sleep loss causally influences intelligence yield from investigative interview participants. By imposing moderate and common levels of sleep loss (losing a half-night of sleep over 2 days), the findings speak to levels of sleep disruption that professional investigators often encounter in their interview participants. The findings indicated that losing even 4–5 h of sleep over 2 days suppressed the amount of information that subjects provided, both initially (7% less) and during a repeat disclosure (5% less). A causal mediation analysis confirmed the role of shortened sleep duration as responsible for these experimental differences. While these percentages should be taken only as estimates given the inherent error in counting pieces of information from subjective ratings, they still speak to substantive consequences of sleep. When extrapolated to numerous interviews that interrogators conduct in the field, these differences imply that multiple pieces of information about crimes (who, what, where, when, why, and how) could be lost when interviewing sleepy participants. For example, across 10 interviews (frequently necessary in homicide investigations), those who lost 5 h of sleep would together provide around 5 fewer verifiable details about who, where, when, what, and how (relative to those who did not lose sleep). These differences were not attributable to being treated differently by the interviewers. Of note, when queried about their interviews,

the sleepier participants tended to report providing more information (when they objectively provided less). While not reaching statistical significance, this results suggests participants did not have insight that sleep loss actually inhibited their disclosures.

Why did sleep loss inhibit criminal history disclosure? Participants' reports of their interview experiences did suggest they liked and felt slightly more comfortable with the interviewers when sleep-restricted, although they did not indicate they were treated differently (see Supplemental Online Materials for results). As these differences were slight and theoretically inconsistent with providing less information (people disclose more to those they like) [38], they are unlikely explanations for differences due to sleep restriction. Note there were no systematic differences in how participants experienced or felt about the events nor the types of crimes they disclosed (see Supplemental Online Materials for results). Finally, note that disclosures about the same event from the same participants were coded independently for pre- and post-model statement accounts; as a result, it is not clear how many of the details provided the second time were new, and whether sleep restriction impacted generation of novel details.

Of note, sleep-restricted individuals exhibited trends toward being less motivated to recall information and finding disclosures more effortful, although these differences did not reach conventional standards of statistical significance. These patterns suggest that increased fatigue due to sleep loss may be one factor worth exploring as the reasons for less disclosure. The model statement increased the amount of information generally, but it did not significantly reduce the deleterious impact of sleep loss. Note that the level of sleep loss was relatively modest in this study, so future research should assess the impact of more severe doses of sleep loss on information yield, which could exert larger effects. Moreover, participants of nighttime interviews (after midnight) could be affected by circadian misalignment in a similar way, with such interviews extremely common [4, 25]. With that said, moderate sleep loss in the context of fact-finding interviews examined here is much more common in everyday law-enforcement than lengthy custodial interviews.

There are important limitations to consider as well. The study did not quite reach the target sample size. More critically, interview participants in this study did not face severe legal consequences as actual suspects would, so whether disclosure would be similarly affected by sleep when the stakes are very high is unclear. In fact, the long passage of time in most cases would mean that the likely consequences would have already occurred. Nevertheless, most investigative interviews involve witnesses, victims, or informants, rather than suspects themselves. In such cases the barriers to disclosures are not necessarily legal, but rather psychological or social (e.g. guilt, shame,

or embarrassment, as in this study). As the power and status and power of the interviewer were relatively low in the current study, it is not clear whether the current dynamics will translate into more high-steak interrogations or those with authority figures. Additionally, the interviewers in this study were not professionals or trained law-enforcement officers. Furthermore, there was no access to ground truth; it is unknown whether individuals actually committed the offenses they acknowledged. However, there are strong pressures against admitting wrong-doing, so it is unlikely that individuals from this population are fabricating serious crimes they did not commit. It is more likely that they failed to disclose offenses. Regardless, random assignment would have equalized such distorting influences across experimental conditions. Note that goal in some interrogations has been to induce confessions regardless of the truth, but the present data does not speak to that particular purpose.

Finally, the exact reasons for less disclosure following sleep loss are only suggested by the data. On one hand, self-reported fatigue and impaired motivation were somewhat related to both sleep loss and lower intelligence yield, but the findings were exploratory. Future research should focus directly on mechanisms that underlie these effects. Note that different doses of sleep loss and different interviewing contexts may involve quite different pathways. For example, the interviews in this study were relatively brief. Surveys of law-enforcement suggest that interviews often last multiple hours [4], which is bound to increase fatigue and may exacerbate the impact of sleep loss.

Conclusions

In sum, sleep loss among investigative interview participants may be a substantive and persistent influence on the amount of information that investigators collect from suspects, victims, and witnesses. As each of these populations are likely to experience sleep disruption during crimes (e.g. due to trauma or need to evade authorities), investigators should consider the sleep history of their interview participants. Anecdotal reports also suggest that interrogators often have to wake up suspects in custody in order to interview them (Personal interview with Det. Matthew Jones). In one New York case, a just-awoken robbery suspect was interviewed for nearly 3 h, even if according to the interviewing detective himself the suspect "seemed like he was dozing off, and we had to stress to him did he understand what was going on" [39]. This further highlights the need to understand how sleep loss impacts interview participants, as well as how sleep inertia (grogginess upon awakening) may impact disclosure. While immediate debriefing or interrogation is advised in many cases (because the participant may be unavailable later, because social influence may contaminate memory, or because others may dissuade participants from reporting), delaying interviews may be advised in certain circumstances to off-load any sleep pressure and aid memory or effort investment. Similar recommendations have been suggested in cases of interviews with law-enforcement following officer-involved shootings, but there are no universal standards [40]. Policy makers should also consider institutional constraints that may impact the extent to which interview participants are sleep-deprived, especially when in custodial environments.

Supplementary material

Supplementary material is available at *SLEEP* online.

Deposit of material in a data repository

All data described in this report, as well as all materials used in this investigation are publicly available in the *Open Science Framework* repository and can be accessed at: //osf.io/yqa4f/.

Disclosure Statement

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