Sleep-readiness signals in insomniacs and good sleepers

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Abstract
Sleep is preceded by physiological and behavioural events that inform the subject that it is time to sleep. Our hypothesis is that insomniacs do not adequately recognize such signals, thus missing the best time to go to bed. Eighty-seven chronic insomniac participants and 76 age-matched good sleeper controls were recruited. Semi-structured interviews focused on three aspects of nocturnal sleep: features, habitual activities and signals that they usually rely on in order to decide their readiness to sleep. The results showed that insomniacs relied more than good sleepers on external signals (time) than on bodily ones to decide to go to sleep.

Keywords
good sleepers, insomniacs, sleep habits, sleep onset, sleep signals

Introduction
Sleep propensity is marked by behavioural events such as blinking and yawning (Baenninger et al., 1996; Kleitman, 1963), and by physiological and psychological ones such as sleepiness, redness of the sclera, difficulty concentrating and difficulty keeping eyes open (Magendie, 1816). The presence of such signals announcing the imminence of sleep suggests that the subject is informed about the most appropriate time to start the sleep episode. However, there are cases in which falling asleep is difficult, such as in many insomniac patients (Schutte-Rodin et al., 2008). These difficulties can depend on a dynamic interplay between psychological and physiological factors. Indeed, cognitive aspects such as excessive rumination and worry at bedtime (Van Egeren et al., 1983) as well as the high level of ‘cortical arousal’ around sleep onset (Hull et al., 1993; Kertesz and Cote, 2011; Lamarche and Ogilvie, 1997) and the heightened sensory processing before sleep (Milner et al., 2009) can make it difficult to fall asleep.

The psychological factors include the well-known bidirectional relationship between insomnia and depression (Harvey et al., 2011;
Taylor et al., 2005). In particular, the impact of insomnia on mental health may be modulated by psychosocial factors such as optimism, level of activities and social engagement (Garms-Homolovà et al., 2010; Sing and Wong, 2011).

Furthermore, insomniac patients have an impaired ability to distinguish between sleeping and waking states (Mercer et al., 2002). Specifically, when insomniacs were awakened from objectively defined sleep (mainly rapid eye movement (REM) and N2 sleep stages), they were much more likely than good sleepers to report having already been awake. Insomniacs’ diminished ability to discriminate between sleep and waking states may be associated with a diminished ability to detect physiological and behavioural signals indicating the imminence of sleep. An impaired ability to recognize sleep signals could lead insomniacs to rely on external cues alone (i.e. time, specific external events such as the end of a TV show) to determine the best sleeping time, thereby leading to a misalignment between the physiological tendency to fall asleep and the subject’s actual attempt to sleep. This discrepancy could reinforce the disorder since the subject would like to sleep but is unable to do so. The aim of this study was to compare insomniac patients with good sleepers, evaluating which signals (physiological, behavioural or external) they rely on to determine their best sleeping time.

Methods

Participants

Eighty-seven chronic insomniac participants (mean age: 51.48 years, standard deviation (SD): 14.21; age range: 17–77 years; 49 females and 38 males) were recruited as controls. Exclusion criteria for the control group were as follows: score >5 at the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989), any pathologies or medications that could alter sleep and night-time shift work. All participants signed an informed consent form to participate in the study. The study received institutional ethical approval.

Procedure

Each participant underwent a semi-structured interview focused on three aspects of nocturnal sleep: features, habits and signals. At first, sleep features such as bedtime, sleep latency, nocturnal and early awakenings were investigated. Then participants were asked to specify their habitual activities carried out before bedtime (i.e. eating, drinking, physical activity). Finally, participants had to report spontaneously the signals on which they usually rely on to decide the most suitable time to lie down with the intention of sleeping. Participants could give more than one answer. Trained interviewers conducted the interviews. Table 1 lists the interview questions.

Data analysis

Sleep habits and activities carried out before bedtime by the two groups were compared throughout using Student’s t-test for independent samples for parametric variables and χ² test for binomial variables. Sleep signals were coded by two independent scorers. Agreement and inter-scorer reliability were quantified using the kappa statistic (Cohen, 1960). Agreement between the two scorers was $k = 0.95$. Categories with fewer than five observations were excluded. Five ‘sleep signal categories’ were identified: yawning, stinging and tired eyes, fatigue, sleepiness and time.

The number of sleep signals mentioned by each participant was compared between insomniacs and good sleepers throughout using Student’s t-test for independent samples.
The frequencies for each ‘sleep signal category’ between the two groups were compared using a $\chi^2$ test. To evaluate a potential gender effect, the frequencies for each ‘sleep signal category’ between males and females within insomniacs and good sleepers were compared using a $\chi^2$ test. The significance level was set at $p < .05$.

Results

Sleep features and sleep habits

Insomniac participants showed a shorter total sleep time, a greater sleep latency, a higher number of awakenings during night-time and an earlier awakening in the morning compared to good sleepers (see Table 2). Furthermore, these patients reported drinking and smoking to a lesser extent than good sleepers (see Table 2).

Sleep signals

The sleep signals mentioned by participants ranged from 1 to 5. Among good sleepers, 39 percent of participants mentioned only one signal, 33 percent two signals, 18 percent three signals, 8 percent four signals and 1 percent five signals. Among insomniacs, 63 percent of participants mentioned only one signal, 32 percent two signals, 3 percent three signals and 1 percent four signals. Good sleepers mentioned a greater number of sleep signals to rely on compared to insomniacs (good sleepers: mean: 1.98, SD: 1.01, range: 1–5; insomniacs: mean: 1.42, SD: 0.62, range: 1–4, $t = 4.19, p < .01$). As shown in Figure 1, a greater number of insomniac participants reported relying on time to decide the most suitable time to lie down with the intention of sleeping ($\chi^2 = 4.61, p < .05$), whereas a greater number of good sleepers reported relying on yawning, stinging and tired eyes and fatigue (yawning: $\chi^2 = 6.32, p < .05$; stinging and tired eyes: $\chi^2 = 10.20, p < .01$; fatigue: $\chi^2 = 8.18, p < .01$). No significant differences between the two groups emerged for sleepiness signal ($\chi^2 = 0.79$, not significant (NS)).

Sleep signals and gender

No significant differences between males and females (Figure 2) were found regarding the
frequencies of each sleep signal category among both good sleepers and insomniacs (good sleepers: yawning, $\chi^2 = 2.66$, NS; stinging and tired eyes, $\chi^2 = 1.46$, NS; fatigue, $\chi^2 = 0.02$, NS; sleepiness, $\chi^2 = 0.80$, NS; time, $\chi^2 = 0.01$, NS; insomniacs: yawning, $\chi^2 = 0.02$, NS; stinging and tired eyes, $\chi^2 = 0.43$, NS; fatigue, $\chi^2 = 0.001$, NS; sleepiness, $\chi^2 = 1.68$, NS; time, $\chi^2 = 0.30$, NS).

### Table 2. Sleep features and sleep habits in good sleepers and insomniacs.

<table>
<thead>
<tr>
<th></th>
<th>Good sleepers</th>
<th>Insomniacs</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total sleep time (hours:minutes; mean ± SD)</td>
<td>7:19 ± 0:54</td>
<td>4:51 ± 1:19</td>
<td>$t = 13.730$</td>
</tr>
<tr>
<td>Bed time (hours:minutes; mean ± SD)</td>
<td>23:28 ± 0:59</td>
<td>23:24 ± 0:58</td>
<td>$t = -0.442$</td>
</tr>
<tr>
<td>Sleep latency (hours:minutes; mean ± SD)</td>
<td>0:09 ± 0:07</td>
<td>0:48 ± 0:56</td>
<td>$t = -6.074$</td>
</tr>
<tr>
<td>Night-time awakenings (%)</td>
<td>47.4</td>
<td>67.8</td>
<td>$\chi^2 = 6.975$</td>
</tr>
<tr>
<td>Awakening numbers</td>
<td>0.66 ± 0.80</td>
<td>2.42 ± 3.26</td>
<td>$t = -4.748$</td>
</tr>
<tr>
<td>Early morning awakening (%)</td>
<td>15.8</td>
<td>63.5</td>
<td>$\chi^2 = 36.05$</td>
</tr>
<tr>
<td>Food (%)</td>
<td>19.7</td>
<td>19.5</td>
<td>$\chi^2 = 0.009$</td>
</tr>
<tr>
<td>Drink (%)</td>
<td>7.9</td>
<td>1.1</td>
<td>$\chi^2 = 4.490$</td>
</tr>
<tr>
<td>Alcohol (%)</td>
<td>14.1</td>
<td>4.6</td>
<td>$\chi^2 = 4.735$</td>
</tr>
<tr>
<td>Nicotine (%)</td>
<td>25</td>
<td>10.3</td>
<td>$\chi^2 = 6.123$</td>
</tr>
<tr>
<td>Physical activity (%)</td>
<td>7.9</td>
<td>9.2</td>
<td>$\chi^2 = 0.087$</td>
</tr>
</tbody>
</table>

SD: standard deviation; NS: not significant.

**Sleep signals and age**

Among good sleepers (Figure 3), a greater number of older participants ($N = 38$) compared to younger people ($N = 38$) rely on sleepiness to determine the most suitable time to lie down with the intention of sleeping ($\chi^2 = 6.08$, $p < .05$), whereas no significant differences between ‘younger’ and ‘older’ emerged for other sleep

![Figure 1. Percentages of good sleepers and insomniacs reporting different sleep-readiness signals. *p < .05, **p < .01.](image-url)
signal categories (yawning: \(\chi^2 = 1.4\), NS; stinging and tired eyes: \(\chi^2 = 0.56\), NS; fatigue: \(\chi^2 = 0.49\), NS; time: \(\chi^2 = 3.52\), NS). Among insomniacs, no differences between ‘younger’ (\(N = 43\)) and ‘older’ (\(N = 44\)) participants were found regarding the frequencies of each sleep signal category (yawning, \(\chi^2 = 0.18\), NS; stinging and tired eyes, \(\chi^2 = 1.03\), NS; fatigue, \(\chi^2 = 2\), NS; sleepiness, \(\chi^2 = 0.18\), NS; time, \(\chi^2 = 1.44\), NS).

**Discussion**

Data collected throughout the interview confirmed differences between good sleepers and insomniac participants in terms of sleep features. However, insomniac patients reported adopting more habits appropriate to good sleep hygiene. Indeed, they reported drinking fewer energy and alcohol beverages and smoking less than good sleepers, although most of the values were low in both groups. A previous study demonstrated that patients with insomnia had more knowledge of sleep hygiene rules than normal sleepers, but adopted them less often (Lacks and Rotert, 1986). In contrast, other studies reported no significant differences in sleep hygiene practices between good sleepers and insomniac patients (Harvey, 2000; Morin and Gramling, 1989). In our study, insomniac participants seemed to adhere to sleep hygiene rules even more than good sleepers and this result can be explained taking into account the chronic insomnia of our patients. Indeed, doctors and the media may have made them more aware of sleep hygiene rules, and therefore, insomniacs were more likely to put them into practice. Moreover, a recent study (Yang et al., 2010) on maladaptive sleep hygiene practices...
in insomniacs found that the only domain of sleep hygiene correlated with insomnia severity was ‘arousal-related behaviours’ (i.e. behaviours promoting awakening or arousal, such as ‘worry not being able to fall asleep in bed’, ‘check the time in the middle of the night’, ‘worry about night-time sleep during the day’, ‘pondering about unresolved matters while lying in bed’). Interestingly, all these behaviours belong to the ‘cognitive’ field rather than to bad habits during the evening or night hours. That study suggested that as chronic insomnia develops, patients start to control only some of the maladaptive sleep hygiene practices, such as eating and drinking before sleep, whereas other dysfunctional habits, such as checking the time and worrying about the ability to sleep, continue as before or are even exacerbated.

Insomniac participants reported relying on fewer signals than good sleepers, indicating insufficient attention to various behavioural, physiological and psychological signals that usually announce the best sleeping time. Indeed, good sleepers reported relying on yawning, stinging and tired eyes and fatigue to a greater extent than insomniacs. By contrast, insomniac patients mainly reported relying on time, that is, an external signal. The importance attributed to time by insomniacs could be due to false beliefs concerning sleep-requirement expectations, such as 8 hours of uninterrupted sleep in order to feel refreshed and function well during the day (Morin et al., 1993, 2002). Indeed, this expectation could lead insomniacs to decide to sleep at a specific, but inappropriate time, probably earlier than their physiological propensity to fall asleep. Some authors (Fernández-Mendoza et al., 2009) reported a higher number of evening types among subjects complaining of insomnia than among good sleepers. Other studies also found evidence that factors such as evening circadian preference may contribute to the perpetuation of insomnia (Adan et al., 2006; Ong et al., 2007).

Sleep signal differences between good sleepers and insomniacs did not seem to be associated with either gender or age. The only significant difference we found concerned sleepiness signals in good sleepers with a higher number of older participants mentioning these signals than younger ones. This difference may be explained in the light of previous results (Zilli et al., 2008) showing higher levels of sleepiness in the evening hours among older participants than younger adults.

The association between insomnia and inappropriate physiological arousal (Bonnet and Arand, 1997; Riemann et al., 2010) may explain the absence of sleep signal differences in younger and older insomniacs. Indeed, studies on physiological differences between good and poor sleepers reported evidence of a greater physiological arousal among poor sleepers (Monroe, 1967). Specifically, rectal temperature, basal skin resistance and phasic vasoconstriction were reported to increase 30 minutes prior to and during sleep in poor sleepers compared to good sleepers. More recent research evaluating insomniac patients confirmed these differences, extending the range of physiological variables (hormone, metabolic, evoked and spectral electroencephalography (EEG) measures) (Bonnet and Arand, 2010). Furthermore, the shorter sleep time and the reported daytime deficits related to reduced sleep do not make insomniacs sleepier during the day. Indeed, objective assessments of sleep propensity during the day in insomniac participants did not show reduced sleep latencies on nap evaluations compared to normal sleepers (Stepanski et al., 1988). The hyperarousal characterizing insomniacs could make it difficult for these patients to refer to sleepiness as a sleep signal, even if sleepiness should increase with age (Zilli et al., 2008). Although no studies have investigated hyperarousal in elderly insomniacs, the common clinical features of primary insomnia in all-age patients suggest that hyperarousal could also be the leading cause of the disease in the older adult population. Physiological features of insomniacs may also explain the negligence towards other internal sleep signals (fatigue, stinging and tired eyes, yawning) shown by these patients.

A twofold hypothesis may account for the insufficient attention paid by insomniacs to
internal signals in order to decide the best sleeping time. These patients may not recognize sleep signals or sleep signals may occur to a lesser extent in insomniacs compared to good sleepers. Indeed, if insomniacs suffer from a disorder of hyperarousal (Bonnet and Arand, 1997; Riemann et al., 2010), their elevated physiological arousal may impair the occurrence of signals usually indicating sleep propensity in normal sleepers.

A limitation of this study is that the method (semi-structured interview) did not allow any of these hypotheses to be confirmed. Further psychophysiological investigations, evaluating signals of sleep propensity throughout the whole 24-hour period, are needed to establish whether insomniac patients have an impaired diminished ability to detect internal sleep signals and whether or not those signals are actually reduced in this population.

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**References**


