ORIGINAL ARTICLE

The Mood Rhythm Instrument: development and preliminary report

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Objective: To describe the initial steps in the development and validation of a new self-reported instrument designed to assess daily rhythms of mood symptoms, namely, the Mood Rhythm Instrument.
Methods: A multidisciplinary group of experts took part in systematic meetings to plan the construction of the instrument. Clarity of items, their relevance to evaluation of mood states, and the consistency of findings in relation to the available evidence on the biological basis of mood disorders were investigated. The internal consistency of the questionnaire was evaluated through Cronbach's alpha.
Results: All of the items proposed in a first version were well rated in terms of clarity. The items more frequently rated as ''rhythmic'' were related to the somatic symptoms of mood. Their peaks in 24 hours were more frequent in the morning. The items associated with affective symptoms of mood were rated as less rhythmic, and their peak in 24 hours occurred more frequently in the afternoon and evening. Males and females behaved more similarly with respect to somatic than behavioral-affective items. The second version of the Mood Rhythm Instrument had a Cronbach's alpha of 0.73.
Conclusion: The proposed Mood Rhythm Instrument may be able to detect individual rhythms of cognitive and behavioral measures associated with mood states. Validation in larger samples and against objective measures of rhythms, such as actigraphy, is warranted.

Keywords: Biological rhythm; mood disorders, bipolar; mood disorders, unipolar; epidemiology; tests/ interview, psychometrics

Introduction

Mammals have an internal oscillator located in the suprachiasmatic nucleus (SCN) of the hypothalamus.[1] This oscillator synchronizes the rhythm of several cellular and physiological functions with the environmental light-dark cycle.[2] Additionally, the SCN receives and integrates information from other external regulators, namely zeitgebers, such as meals, physical activity, and social interactions, in order to prepare the body for these functions.[3]

In the central nervous system, the net effect of this complex regulatory circadian system is the rhythmic modulation of neurotransmitters and neuromodulators.[1] This rhythmic modulation has wide-ranging implications for behavioral and neurobiological functions including mood, learning, memory, motor activity, hormone secretion, temperature, food intake, and sleep.[2,3]

It has been well established that abnormalities in the sleep-wake cycle and in rest-activity circadian rhythms are associated with changes in mood states. This relationship has been observed at the molecular, physiological, and behavioral levels.[4] However, little is known about the 24-hour rhythm of other behavioral and physiological functions, such as mood, cognitive abilities, appetite, and social interaction.

Daily human behavior has mainly been assessed by questionnaires designed to describe individuals' temporal preferences.[5] The most commonly used questionnaires are the Morningness-Eveningness Questionnaire (MEQ) and the Munich ChronoType Questionnaire (MCTQ).[6-9] More recently, the Biological Rhythms Interview of Assessment in Neuropsychiatry (BRIAN) was developed to assess rhythm changes in a sample of subjects already affected by mood disorders.[10]

We are unaware of any instrument developed to evaluate daily rhythms of mood symptoms. The present report describes the initial steps in the development and validation of a new self-reported instrument designed for this purpose, the Mood Rhythm Instrument.

Methods

Subjects

Participants were recruited from the general population. To be eligible for the study, potential participants had to

be able to understand the instrument's questions. Night shift workers, those who had traveled across time zones in the last week, and those with any disabling diseases were ineligible.

Experts working group

A multidisciplinary group of senior psychiatrists, a senior psychologist, and a nutritionist met on 12 occasions with the objective of developing an instrument to evaluate the daily occurrence of mood-related behaviors and physiological functions in the general population. The DSM-5 criteria[11] for depressive episode were used to model some of the items, while other items were proposed on the basis of clinical experience in the management of patients with mood disorders. The group also carefully discussed and agreed on item wording, the order of the questions, and the format of the answers. Development of the instrument was guided by the steps described by Holmbeck et al.[12] A flowchart of the process is depicted in Figure 1.

First version

Seventeen self-reported items composed the first version of the instrument. Study participants were asked to report dichotomously (yes/no) whether each behavior or physiological need had a peak during the 24 hours of the day. Participants were instructed to indicate this peak on a visual analog scale (VAS) representing each hour interval of the day. Then, the clarity of the questions was rated on a VAS ranging from 0 (not clear) to 10 (very clear). At the end, participants were asked to write comments and suggestions on the instrument. This version was administered to a convenience sample of 30 individuals from the general population.

Second version

The second version was built based on the feedback from the first experiment and from critical review by the group of experts. Although all items were considered easy to understand, we modified some of the questions to further improve comprehension. Additionally, we excluded three questions (regarding disposition, energy for daily activities, and tiredness) due to redundancy. Two other questions (regarding interest in the environment and interest in relationships) were excluded because participants found that these feelings did not peak at any time of the day. Furthermore, we included at the beginning of the instrument two examples of how to answer questions, and participants were asked to consider the last 15 days when filling out the questionnaire, taking into account how they felt most of the time during this period. The
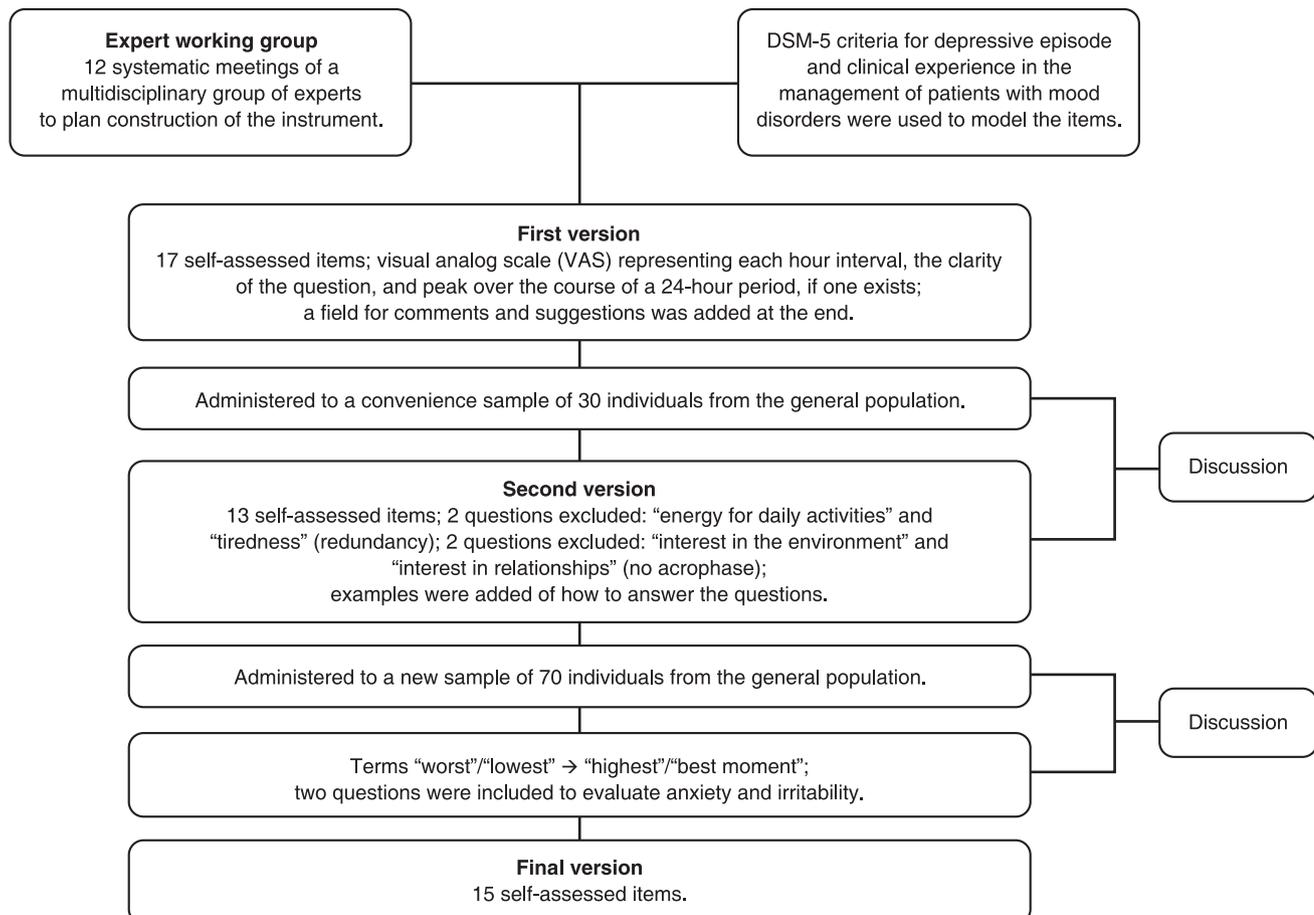
Figure 1 Flowchart of development of the Mood Rhythm Instrument.

second version, consisting of 13 self-reported items, was then administered to 70 new individuals from the general population.

Final version

For the final version, we reformatted the items of the questionnaire to ask about the "highest" or "best" moment for all investigated behaviors or physiological needs, rather than the "lowest" or "worst" moment. This included modification of the question that addressed motivation to practice physical exercise, which in the previous versions asked for the worst moment of the day for this activity. In addition, we decided to include two additional questions to evaluate anxiety and irritability. The final version is composed of 15 items.

Statistical analysis

All data were analyzed in PASW Statistics, Version 18. Categorical variables are shown as absolute and relative frequency, and continuous variables, as mean ± standard deviation. The peak in 24 hours of each variable was analyzed by the Rayleigh test and is presented as the mode.

The internal consistency of the instrument was measured with Cronbach's alpha. A value between 0.7 and 0.9 was considered satisfactory.[13]

Ethical aspects

This study was performed according to international ethical guidelines (ethics committee approval: no. 15-0266, GPPG/HCPA).[14]

Results

At the first and second assessments, the mean age of participants was 35.67±16.25 and 35.99±15.62 years respectively, and the average educational attainment was 15.13±4.08 and 14.52±4.10 years of schooling. Women represented 63.3 and 54.3% of the study sample in these two assessments.

Table 1 lists questions from the first version and their evaluations. Table 2 reports, separately for male and female sex, the frequency with which individuals perceived each of the evaluated items as presenting with a daily peak. Females more frequently perceived a peak for daily alertness than males (χ^2 = 8.37, p ⩽ 0.01).

Figure 2 shows, separately for men and women, the frequency with which respondents perceived each of the evaluated items as presenting with a daily peak and the time of day or night most commonly reported as the daily peak. Two distinct clusters were identified: one of items showing an early-morning peak, which were most frequently rated as rhythmic (by at least 70% of individuals), and a second, less rhythmic cluster with peaks occurring later in the afternoon.

Figure 3 shows the distribution of respondents' reported peaks for the items of the second version of the instrument, separated by sex.

The second version of the proposed instrument presented a Cronbach's alpha of 0.73.

Discussion

The main finding of this study is that certain variables, such as sleepiness, alertness, concentration, problem-solving, learning, and appetite, were commonly perceived as peaking at a certain time of day (Figure 2). These variables are mostly related to somatic symptoms, were similarly distributed in men and women, and the time of their peak during the 24-hour day tended to cluster in the morning (Figure 2). These findings are in accordance with previous studies showing that mood is synchronized with the rhythm of physiological variables such as body temperature and cortisol and melatonin secretion.[15] However, in studies performed in laboratory settings when participants were exposed to constant routines, these peaks primarily occurred during the evening.[15] It is possible that some of the variables in our study may have been influenced by zeitgebers such as work or school, which usually start in the morning.

Among the cluster of predominantly cognitive-affective variables such as self-esteem, sadness, social networks, sexual arousal, and talking to friends, a daily peak was reported less often, with a wider distribution between the morning and evening periods, and with 24-hour peaks occurring at different time points in men and women (Figure 2).

As one might expect, sleepiness and alertness had opposite rhythms (Figure 3). Peaks of sleepiness early in the morning (7:00 a.m.) were followed by peaks of alertness (8:00-11:00 a.m.). A decrease in alertness was followed by a new peak in the early evening (6:00-8:00 p.m.), with a subsequent decrease thereafter.[16] The inclusion of sleepiness and alertness in an instrument

Table 1 First version items and evaluation for clarity

Item (n)	Feeling...	Clarity (mean)
1 (29)	... in your best disposition...	9.42
2 (29)	... most tired...	9.40
3 (28)	... the highest alertness...	9.48
4 (29)	... sleepiest...	9.62
5 (18)*	... most interested in the environment...	9.05
5 (10)*	... highest ability to solve problems...	8.97
6 (29)	... greatest energy to perform daily activities...	9.35
7 (29)	... best self-esteem...	9.33
8 (29)	... the highest concentration...	9.65
9 (29)	... greatest appetite...	9.48
10 (26)	... most sexually aroused...	9.59
11 (27)	... most interested in relationships...	9.17
12 (28)	... most interested in talking personally to friends...	9.57
13 (28)	... most interested in connecting through social networks...	9.74
14 (28)	... worst sadness...	9.70
15 (28)	... lowest disposition to work out...	9.67
16 (28)	... best ability to learn...	9.57
17 (26)	... most pessimistic...	9.28

* The question on environment was replaced by the question on solving problems.

Table 2 Frequency of rhythmicity indicated for each item of the second version, stratified by sex

Item	Feeling...	Female	Male
1	... the highest alertness...	57 (91.23)	41 (68.29*)
2	... sleepiest...	57 (94.74)	40 (87.80)
3	... highest ability to solve problems...	46 (61.40)	34 (65.83)
4	... best self-esteem...	57 (45.61)	41 (46.34)
5	... the highest concentration...	57 (80.70)	41 (75.61)
6	... greatest appetite...	57 (87.72)	41 (90.24)
7	... most sexually aroused...	56 (31.58)	41 (46.34)
8	... most interested in talking personally to friends...	57 (31.58)	41 (19.51)
9	... most interested in connecting through social networks...	57 (36.84)	41 (34.15)
10	... worst sadness...	57 (31.57)	41 (31.71)
11	... lowest disposition to work out...	55 (75.44)	41 (73.17)
12	... best ability to learn...	56 (73.68)	41 (65.85)
13	... most pessimistic...	56 (26.32)	41 (21.95)

Data presented as n (%).
*$p \leqslant 0.01$.

evaluating biological rhythms and their impact on health is important because these are reliable markers of individual time structure and tend to maintain a reproducible circadian rhythm under normal conditions,[17] thus allowing for the differentiation between health and disease. For further studies, sleep debt and the quality and intensity of exposure to light should be evaluated, as stated by Spiegel et al.[18] and Leproult et al.,[19] because these factors significantly affect melatonin and cortisol secretion and thus influence sleepiness and alertness.

The rhythms of cognitive variables such as attention, learning, and ability to solve problems peaked more frequently in the morning. This result is in agreement with the findings of Wright et al., who described that several cognitive tasks were better performed in the morning and that cognitive performance correlated with individuals' rhythm of body temperature.[20] More recently, an experimental study in rats suggested that cognitive tasks could act as zeitgebers when animals entrained their rest-activity rhythms to cognitive training episodes. A non-photic system based on cholinergic projections was thought to be implicated in this regulation.[21] Most working schedules start early in the morning and, under normal conditions, can both influence and be influenced by this physiological rhythm. The well-established cognitive

dysfunction associated with mood episodes further supports the inclusion of these items in a Mood Rhythm Instrument.

The reciprocal rhythm of leptin and ghrelin is considered an important mechanism in the regulation of food intake. Ghrelin induces food intake and its levels peak during the night and in the morning,[22,23] increasing hunger at lunchtime.[24] In many cultures, appetite is influenced by social routines and by the availability of meals. Therefore, it is not surprising that, in our study, most individuals reported the peak time of appetite at noon. Schimitt & Hidalgo[25] reported that lunchtime was a stronger social zeitgeber in a Brazilian sample than in individuals from the U.S.

Items assessing cognitive-affective variables such as self-esteem, social networks, sadness, talking to friends, sexual arousal, and pessimism were less perceived as having a daily peak; they occurred more frequently in the evening and differences between the sexes were evident. As a result, mood rhythm assessments should be performed separately in men and women. In psychiatric disorders, social functioning is often compromised; therefore, investigation of social rhythm is also important. Interestingly, items assessing affective and social variables displayed a noticeable variance in their pattern of
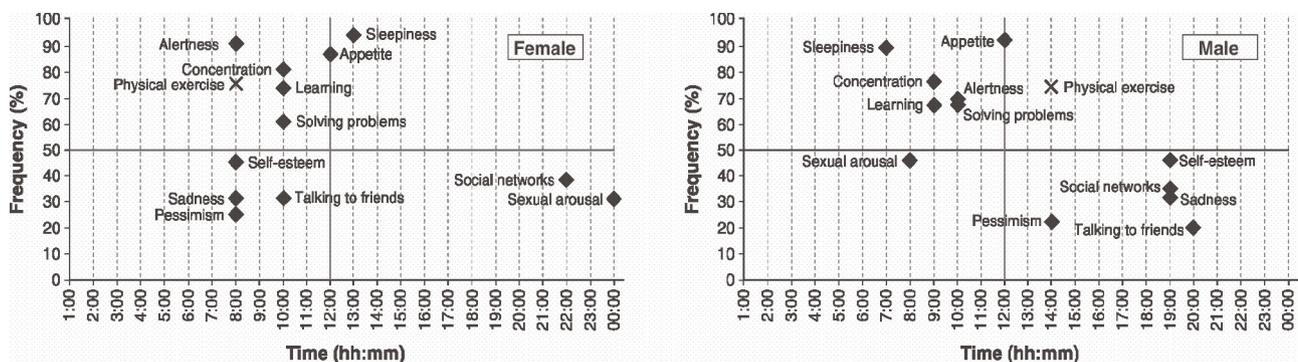
Figure 2 24-hour peaks of behaviors and physiological needs (x) and frequency of respondents who perceived rhythmicity during a 24-hour period (y), stratified by sex. Physical exercise is indicated by the peak of lowest occurrence (time at which least willing to engage in exercise).
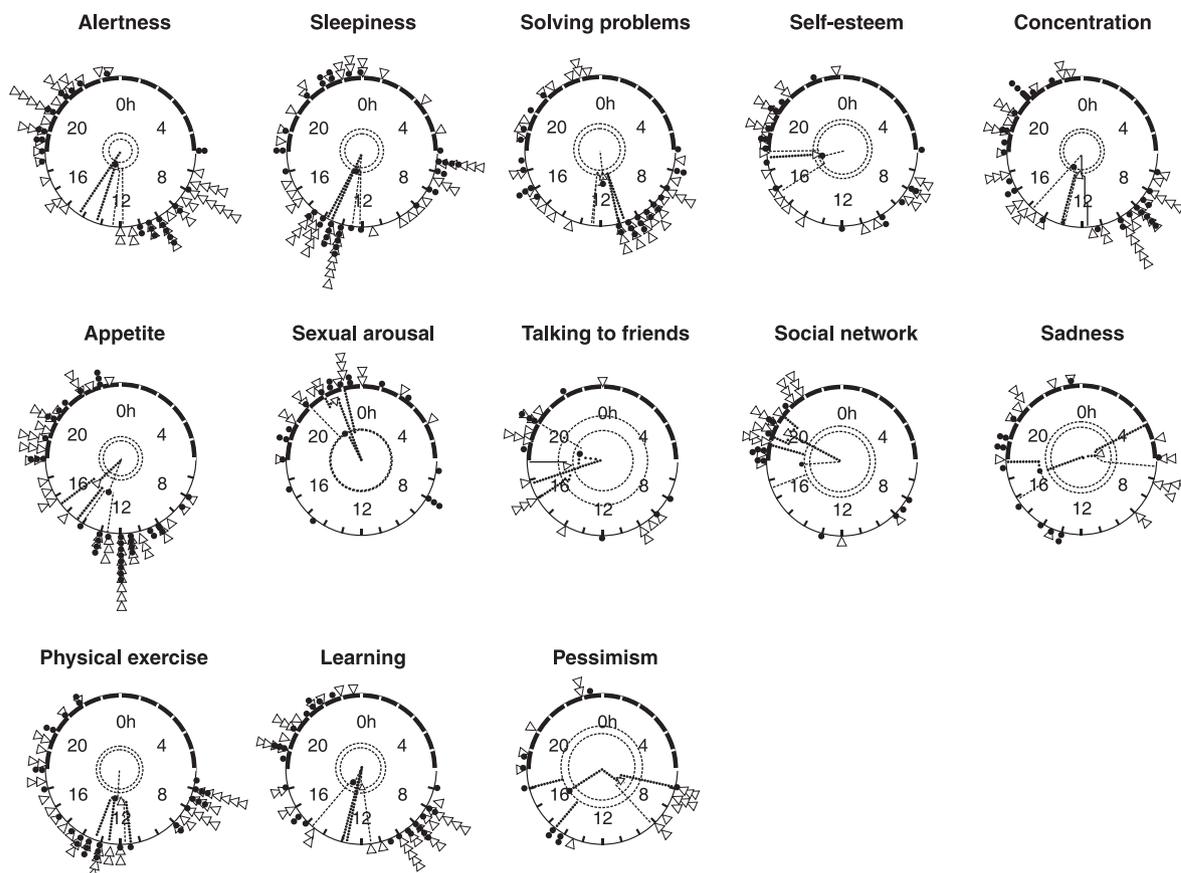
Figure 3 Reported peaks for the items investigated in the second version of the questionnaire, separated by sex.Circles represent the 24-hour day.The arc highlighted in black represents the average night.Triangles and dots represent female and male respondents respectively. *Physical exercise is indicated by the peak of lowest occurrence (time at which least willing to engage in exercise).

distribution through the 24-hour period. From a theoretical perspective, in modern life, work is the main social activity and is known to be an important zeitgeber. However, it has been suggested that work schedules may entrain our rhythms accordingly to societal needs rather than to physiological needs.[25]

The second version of the Mood Rhythm Instrument showed good internal consistency; questions are coherent with one another and have minimal overlap. All items were well rated in terms of clarity. While these preliminary results are encouraging, the next steps will be to test the performance of the Mood Rhythm Instrument in larger samples from the general population and from clinical settings.

The link between disruption of circadian rhythms and mood disorders has been well established. This Mood Rhythm Instrument seems able to detect changes in rhythms of cognitive and behavioral variables related to mood states and, therefore, may be useful in epidemiological and clinical studies.

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Disclosure

The authors report no conflicts of interest.

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