Abstract. Morningness-eveningness refers to the preference people have regarding the time they like to rise, conduct activities, and go to bed. People denoted as “morning types” (“larks”) like to rise early in the morning and go to bed early, while “evening types” (“owls”) prefer to sleep until later in the day and stay up until later at night. Various self-report instruments that measure morningness-eveningness have been developed. The aim of this study was to validate seven different self-report measures on morningness-eveningness using actigraphic data. One hundred and sixty-six students (mean age 21.4 years, range 19–30) were recruited from the University of Bergen and Bergen University College. The participants completed the self-report measures and wore an actigraph for seven days. The results showed that all self-report measures were in concordance with actigraphy-measured bed times, rise times, and the nadir for physical activity. In addition, some of the instruments were sensitive to differences between morning and evening types in their total sleep time on weekend nights or their stability in the activity curve across days as measured by actigraphy. Both the strengths and weaknesses of the present study are discussed, and proposals for future research are presented.

Keywords: circadian rhythms, morningness-eveningness, actigraphy, sleep, physical activity

In general, human beings are a diurnal species. Still, some interindividual differences exist, leading to various preferences in rise times, times for conducting daily activities, and bed times. These differences are assumed to reflect a more or less stable trait often referred to as morningness-eveningness (ME; Natale & Cicogna, 2002). The two ends of this trait continuum are represented by people characterized as morning types and evening types, respectively, while most people can best be characterized as intermediate types. Under conditions of free choice, people denoted as morning types (“larks”) like to rise early in the morning and go to bed early, while evening types (“owls”) prefer to sleep until later in the day and stay up until later at night. Studies have shown that the ME trait is associated with the phase of different circadian rhythms. For instance, morning types have an earlier acrophase (peak time) for both core body temperature (Natale & Alzani, 2001) and hormone secretion (Bailey & Heitkemper, 2001; Duffy, Dijk, Hall, & Czeisler, 1999) than evening types.

Scores for the ME dimension have been found to correlate with several sleep variables. Studies utilizing subjective measures of sleep have found that evening types typically seem to sleep less than morning types on weeknights, although they sleep more on weekend nights (Giannotti, Cortesi, Sebastiani, & Ottaviano, 2002; Taillard, Philip, & Bioulac, 1999). Evening types seem to experience a poorer quality of sleep (Gaina et al., 2006; Giannotti et al., 2002; Megdal & Schernhammer, 2007) and report a larger need for sleep (Taillard et al., 1999) than morning types. Fewer studies have investigated the relationship between the ME dimension and other measures of sleep and circadian rhythms such as actigraphy. Actigraphy is an objective method for measuring sleep-wake cycles and activity levels. An actigraph consists of an accelerometer and memory storage, both of which are contained in a watch-like device worn on the wrist. Based upon an algorithm, the data stored in the device can be used for the calculation of sleep parameters. Although actigraphy is regarded as a reliable and valid...
instrument for monitoring sleep in the general, healthy population (Littner et al., 2003), it may be necessary to take recordings on multiple nights in order to obtain the most reliable estimates (Tworoger, Davis, Vitiello, Lentz, & McTiernan, 2005). To date, only a few studies have used actigraphy to investigate the relationship between sleep parameters and ME. In two studies, an ME questionnaire investigated students wearing actigraphs for three consecutive nights, and both studies showed an earlier physical activity phase in morning types compared to evening types (Natale, Esposito, Martoni, & Fabbri, 2006; Natale et al., 2006). A similar finding was obtained from a study of 60 high school students, validating another ME questionnaire against actigraphic recordings for seven consecutive days (Tonetti, 2007).

However, to the best of our knowledge the relationship between activity and ME has not yet been investigated using rather new actigraphic parameters such as inter-daily stability (indicating the invariability of the 24-hr rhythm across days) and intra-daily variability (which is based on changes in hourly activity levels and gives an indication of the fragmentation of the rhythm). Taking into account that evening types generally show more irregular sleep-wake pattern than morning types, one can hypothesize that evening types will have lower inter-daily stability scores than morning types.

The ME dimension is usually measured by different self-report instruments which regard this dimension as a stable trait. The Horne-Östberg Morningness-Eveningness Questionnaire (Horne & Östberg, 1976) was the first self-report instrument aimed at measuring this dimension, and is still widely used. A number of other instruments have subsequently been developed, including the Horne-Östberg Morningness-Eveningness Questionnaire – a Reduced Scale (Adan & Almirall, 1991), the Diurnal Scale (Torsvall & Åkerstedt, 1980), the Composite Scale (Smith, Reilly, & Midkiff, 1989), the Basic Language Morningness Scale (Brown, 1993), the Early/Late Preference Scale (Smith et al., 1993), and the Student Morningness-Eveningness Questionnaire (Koscec, Radosevic-Vidadeć, & Kostovic, 2001).

The aim of this study was to validate these seven ME instruments using actigraphic data. These instruments were chosen since they seem to be the ones most frequently used in studies of the ME dimension. The Munich Chronotype Questionnaire (Roenneberg et al., 2007) is often used as well, although this instrument measures sleep midpoint rather than the ME dimension. Only a few studies have used actigraphic data to explore the differences between morning and evening types, and no single study has ever validated as many as seven different measures of the ME dimension. Furthermore, most actigraphic studies of the ME dimension which have been carried out up until now have used a relatively low number (< 100) of subjects. The novel aspect of this study is that it serves as an attempt to compare the validity of not only one, but seven different questionnaires measuring ME. In addition, no previous study has investigated ME questionnaires against actigraphic parameters such as inter-daily stability and intra-daily variability.

We hypothesized that there would be a negative correlation between morningness scores and bed times, rise times, sleep time on weekends, and nadir (time for lowest level) of activity. On the other hand, we assumed that there would be a positive correlation between morningness scores and sleep time on weeknights and inter-daily stability. When categorizing subjects as morning types or evening types we expected data derived from the actigraphic measures to confirm that: (a) morning types go to bed and rise earlier than evening types, (b) evening types have a shorter total sleep time than morning types on weeknights and a longer total sleep time on weekend nights, (c) morning types have an earlier nadir for physical activity than evening types, and (d) although morning types have a higher inter-daily stability with respect to activity than evening types, they do not differ from evening types in terms of intra-daily variability.

**Methods**

**Participants**

One hundred and sixty-six students from the University of Bergen and Bergen University College in Norway volunteered to participate in our study, with the majority of the students enrolled in introductory psychology or mathematics courses. Ninety-three of the students (56%) were women and 73 (44%) were men, and the mean age was 21.4 years (SD = 2.2, range = 19–30).

**Instruments**

**Horne-Östberg Morningness-Eveningness Questionnaire (Horne & Östberg, 1976)**

The Horne-Östberg Morningness-Eveningness Questionnaire is composed of 19 items and is aimed at measuring several aspects of morningness, including sleep habits, sleepiness, and the preferred time for performing activities that require physical or mental alertness. In total, 14 of the items are on a Likert scale format with four response alternatives, and for the five remaining items, the answers are marked along a continuum. The scoring range of the Horne-Östberg Morningness-Eveningness Questionnaire is 16–86, with higher scores indicating a higher degree of morningness. Computer calculations showed that Cronbach’s alpha for Horne-Östberg Morningness-Eveningness Questionnaire in this study was .81.

**Horne-Östberg Morningness-Eveningness Questionnaire – a Reduced Scale (Adan & Almirall, 1991)**

This is a revised and shortened version of the Horne-Östberg Morningness-Eveningness Questionnaire, consisting of five items from the original (Items 1, 7, 10, 18, and 19). These items cover preferred rise time, tiredness in the morning, time of feeling tired in the evening, time of perceived
optimal functioning during the day, and the self-perception of being a morning or evening type of person. The scale correlates closely with the Horne-Östberg Morningness-Eveningness Questionnaire (Adan & Almirall, 1991). Cronbach’s alpha for the short version of the Horne-Östberg Morningness-Eveningness Questionnaire in this study was .59, with the low correlation due to the instrument only consisting of five items.

Diurnal Scale (Torsvall & Åkerstedt, 1980)

The Diurnal Scale consists of seven items aimed at measuring diurnal preferences independently of habitual work times. Each item has four Likert scale response alternatives. High scores indicate a high degree of morningness. Cronbach’s alpha for the Diurnal Scale in this study was .69.

Composite Scale (Smith et al., 1989)

The Composite Scale consists of 13 items and is based on a factor analysis of the items from the Morningness-Eveningness Questionnaire and from the Diurnal Scale. The Composite Scale measures preferred times for going to bed and rising, and for performing certain activities when there are no external (social) demands influencing these actions. Cronbach’s alpha for the Composite Scale in this study was .89.

Basic Language Morningness Scale (Brown, 1993)

The Basic Language Morningness Scale consists of the same items as the Composite Scale, but stated in a more simplified language. High scores indicate a high degree of morningness. Cronbach’s alpha for the Basic Language Morningness Scale in this study was .88.

Early/Late Preference Scale (Smith et al., 1993)

The Early/Late Preference Scale consists of 12 items aimed at measuring the subject’s perception of his or her own diurnal preferences relative to those of other people. High scores indicate a high degree of morningness. Cronbach’s alpha for the Early/Late Preference Scale in this study was .89.

Student Morningness-Eveningness Questionnaire (Koscec et al., 2001)

The Student Morningness-Eveningness Questionnaire consists of 12 items which measure daily habits concerning sleep, sleepiness, meals, and study/work. Some of the questions are open (the subject must provide a time estimate) while others are closed (the subject must choose among three to five alternatives). Unlike the other instruments, a high score on the Student Morningness-Eveningness Questionnaire indicates a low degree of morningness. Cronbach’s alpha for the Student Morningness-Eveningness Questionnaire in this study was .72.

Actigraphy

The actigraphic model chosen for this project was the AW7, produced by Cambridge Neurotechnology Ltd., UK (http://www.camntech.com/). It contains a piezo-electric accelerometer. In order to remove noise from sources of movements other than limb movements, filters are set to 3 and 11 Hz. By the use of an event button, the time spent in and out of bed can be distinguished. In contrast to many previous actigraph models the AW7 is completely waterproof, so the participants were instructed to keep it on when showering or bathing – thereby resulting in continuous recordings. The software “Activwatch activity and sleep analysis” (version 7.22) was used to score the actigraphy data. An epoch length of 1 min was chosen, and the sensitivity was set to medium. The sleep parameters bed time, rise time, and total sleep time, as well as the activity parameters nadir (based on the midpoint of the five consecutive hours with the lowest activity), inter-daily stability, and intra-daily variability, were calculated. The parameters chosen for analyses were bed time, rise time, total sleep time (divided between weeknights and weekend nights), nadir, inter-daily stability, and intra-daily variability. The calculation of the two latter stability measures is described by Van Sommener et al. (1999). These parameters were emphasized since we regard these as being the most relevant for the ME dimension. Figure 1 shows an example of an actogram for a morning type and an evening type, respectively.

Procedure

Recruitment took place at lectures held at the University of Bergen and Bergen University College. The participants were informed of the aim of the project and the methods involved, and signed a consent form at the outset. They then received the instruments and put on the actigraph, which they were asked to wear on their nondominant wrist, and the participants received both written and oral instructions on how to use the device. The actigraph was continuously worn for seven days, and the self-report instruments were completed during the same week. The participants were instructed to complete the ME questionnaires during the seven-day period in which they wore the actigraph, and the original instructions for each instrument were given. Norwegian versions of the self-report measures were used, all of which had been subjected to a translation-back translation procedure. The data collection took place from January 2008 to April 2008, and each student received a compensation of NOK 250 (roughly €30) for their participation. The project was approved by the Regional Committee for Medical Research Ethics in Western Norway (REK Vest). The Norwegian Social Science Data Services granted permission to create an individual database/person register. A total of 40 actigraphs were made available for the project.
Statistical Analyses

SPSS for Windows (version 15.0) was used to statistically analyze the data. The relationship between the various actigraphic parameters and the ME inventories was calculated using Pearson’s product-moment correlation coefficient. In addition, the scores of each instrument which measured the ME dimension were divided into separate quartiles for each instrument. The participants who scored in the upper and lower quartiles were assigned either to a morning type group or an evening type group, respectively. The t-tests for independent samples were then conducted in order to study the differences between the morning and evening type groups in terms of sleep and circadian rhythm variables (bed time, rise time, total sleep time on weeknights, total sleep time on weekend nights, nadir, inter-daily stability, and intra-daily variability). Separate analyses were conducted for each instrument. In order to provide estimates of the magnitude of the differences between the two groups’ effect sizes, Cohen’s $d$, which reflects the differences in mean divided by the pooled standard deviations, was calculated (Cohen, 1977). A general guideline for interpreting the $d$ value is that a $d$ value of 0.20 is small, a $d$ value of 0.50 is moderate, and a $d$ value of 0.80 is large (Cohen, 1977). As separate analyses were conducted for each instrument a Bonferroni correction was used to avoid capitalize on the risk for type I errors.

Results

The basic statistics for all seven scales are presented in Table 1.

Relationships Between the Different ME Measures

The relationships between each of the seven instruments which measure the ME dimension are shown in Table 2. All correlations were significant ($p < .01$), ranging from .71 to .92. In part, the correlations are strong because some of the instruments consisted of the same items.

Relationships Between the ME Measures and the Actigraphic Parameters

The relationships between each of the instruments and the sleep and activity parameters are shown in Table 3. All ME measures correlated significantly ($p < .01$) with bed

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Range</th>
<th>Mean</th>
<th>Median</th>
<th>Mode</th>
<th>SD</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horne-Östberg Morningness-Eveningness Questionnaire</td>
<td>25–64</td>
<td>47.7</td>
<td>48.0</td>
<td>52.0</td>
<td>8.1</td>
<td>−0.45</td>
<td>0.10</td>
</tr>
<tr>
<td>Diurnal Scale</td>
<td>8–24</td>
<td>16.1</td>
<td>16.0</td>
<td>14.0</td>
<td>3.4</td>
<td>0.02</td>
<td>−0.56</td>
</tr>
<tr>
<td>Early/Late Preference Scale</td>
<td>17–49</td>
<td>33.4</td>
<td>34.0</td>
<td>35.0</td>
<td>6.5</td>
<td>−0.15</td>
<td>0.26</td>
</tr>
<tr>
<td>Composite Scale</td>
<td>15–48</td>
<td>33.2</td>
<td>33.0</td>
<td>38.0</td>
<td>6.4</td>
<td>−0.28</td>
<td>−0.28</td>
</tr>
<tr>
<td>Basic Language Morningness Scale</td>
<td>16–50</td>
<td>32.7</td>
<td>33.0</td>
<td>33.0</td>
<td>6.5</td>
<td>−0.20</td>
<td>−0.28</td>
</tr>
<tr>
<td>Student Morningness-Eveningness Scale</td>
<td>4–22</td>
<td>11.1</td>
<td>11.0</td>
<td>13.0</td>
<td>3.8</td>
<td>0.20</td>
<td>−0.56</td>
</tr>
<tr>
<td>Horne-Östberg Reduced Scale</td>
<td>6–21</td>
<td>13.4</td>
<td>14.0</td>
<td>16.0</td>
<td>3.0</td>
<td>−0.28</td>
<td>−0.25</td>
</tr>
</tbody>
</table>
Table 2. Pearson’s product-moment correlation coefficients between the different ME measures

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Diurnal Scale</th>
<th>Early/Late Preference Scale</th>
<th>Basic Language Morningness Scale</th>
<th>Composite Scale</th>
<th>Student Morningness-Eveningness Questionnaire</th>
<th>Horne-Östberg Reduced Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horne-Östberg Morningness-Eveningness Questionnaire</td>
<td>.80**</td>
<td>.77**</td>
<td>.86**</td>
<td>.87**</td>
<td>-.76**</td>
<td>.92**</td>
</tr>
<tr>
<td>Diurnal Scale</td>
<td>.72**</td>
<td>.80**</td>
<td>.87**</td>
<td></td>
<td>-.74**</td>
<td>.76**</td>
</tr>
<tr>
<td>Early/Late Preference Scale</td>
<td></td>
<td>.78**</td>
<td>.91**</td>
<td></td>
<td>-.71**</td>
<td>.75**</td>
</tr>
<tr>
<td>Basic Language Morningness Scale</td>
<td></td>
<td></td>
<td>.91**</td>
<td></td>
<td>-.71**</td>
<td>.84**</td>
</tr>
<tr>
<td>Composite Scale</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.74**</td>
<td>.87**</td>
</tr>
<tr>
<td>Student Morningness-Eveningness Questionnaire</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.72**</td>
</tr>
</tbody>
</table>

Note. **p < .01 (Bonferroni correction).

Table 3. Pearson’s product-moment correlation coefficients between the ME measures and the actigraphic measures

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Bed time</th>
<th>Rise time</th>
<th>Total sleep time weeknights</th>
<th>Total sleep time weekend nights</th>
<th>Nadir</th>
<th>Inter-daily stability</th>
<th>Intra-daily variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horne-Östberg Morningness-Eveningness Questionnaire</td>
<td>- .56**</td>
<td>- .53**</td>
<td>-.03</td>
<td>- .10</td>
<td>-.47**</td>
<td>.09</td>
<td>-.07</td>
</tr>
<tr>
<td>Diurnal Scale</td>
<td>-.54**</td>
<td>-.52**</td>
<td>-.00</td>
<td>- .11</td>
<td>-.43**</td>
<td>.12</td>
<td>-.06</td>
</tr>
<tr>
<td>Early/Late Preference Scale</td>
<td>-.53**</td>
<td>-.52**</td>
<td>-.10</td>
<td>- .07</td>
<td>-.45**</td>
<td>.21</td>
<td>-.07</td>
</tr>
<tr>
<td>Basic Language Morningness Scale</td>
<td>-.54**</td>
<td>-.53**</td>
<td>-.05</td>
<td>- .12</td>
<td>-.51**</td>
<td>.14</td>
<td>-.11</td>
</tr>
<tr>
<td>Composite Scale</td>
<td>-.55**</td>
<td>-.57**</td>
<td>-.07</td>
<td>- .19</td>
<td>-.51**</td>
<td>.09</td>
<td>-.09</td>
</tr>
<tr>
<td>Student Morningness-Eveningness Questionnaire</td>
<td>.62**</td>
<td>.65**</td>
<td>.07</td>
<td>.11</td>
<td>.50**</td>
<td>-.07</td>
<td>.03</td>
</tr>
</tbody>
</table>

Note. **p < .01 (Bonferroni correction).
times, rise times, and nadir. The correlations were positive for all instruments except Student Morningness-Eveningness Questionnaire since high scores on this measure represent low degrees of morningness.

Sleep Parameters in Morning Types and Evening Types

Morning types measured by the seven self-report measures of the ME dimension had significantly earlier bed times and rise times than evening types when measured by actigraphy (Table 4). The effect sizes were large. The average bed time (across all seven measures) for morning types was 23:54, whereas the average bed time for evening types was 01:08. The average rise time for morning types (across all seven measures) was 08:19, whereas the average rise time for evening types was 09:53.

There were no significant differences between the morning type group and the evening type group with respect to total sleep time on weeknights, but for weekend nights, the evening types had a significantly longer total sleep time than morning types on the Composite Scale ($t = 2.9$, $p < .05$, $d = .63$) (data not shown). The mean total sleep time on weekend nights across all instruments was 7 hr 02 min for morning types and 7 hr 43 min for evening types.

The averages across all instruments were calculated using a procedure in which all participants were allocated to one group (morning or evening type), based on such a classification by at least one of the seven ME questionnaires. With respect to activity, morning types had a significantly lower nadir as measured by actigraphy than evening types for all seven self-report measures (Table 5). The effect sizes were large. The average nadir time (across all seven measures) was 04:04 for morning types and 05:23 for evening types. As far as inter-daily stability is concerned, one instrument (the Early/Late Preference Scale) showed that morning types had a significantly higher inter-daily stability than evening types ($t = 2.6$, $p < .05$, $d = .58$). Nevertheless, this was the only instrument that demonstrated this result. No significant differences between morning types and evening types in terms of intra-daily variability were found by any of the seven measures.

Discussion

The mean and the median for all seven instruments were fairly equal, the skewness and kurtosis did not depart much from zero for any instrument, and Q-Q plots indicated normality. In sum, the scores on all seven ME instruments were close to being normally distributed.

The results from the $t$-tests for all seven self-report measures of the ME dimension showed that subjects classified as morning types went to bed and rose significantly earlier than evening types according to the actigraphy. The correlational analysis also found a significant negative correlation between morningness scores and bed time/rise time as measured by actigraphy. As a result, the self-report instruments

Table 4. Independent samples $t$-tests for the differences between the morning type group and the evening type group in terms of actigraphy-measured bed times and rise times

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Morning types</th>
<th>Evening types</th>
<th>$t$-value</th>
<th>$d$-value</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horne-O¨ stberg Morningness-Eveningness Questionnaire</td>
<td>43 23:55 49.2</td>
<td>37 01:24 87.6</td>
<td>5.4**</td>
<td>1.28</td>
<td>0.000</td>
</tr>
<tr>
<td>Diurnal Scale</td>
<td>39 23:50 42.4</td>
<td>39 01:07 82.3</td>
<td>5.9**</td>
<td>1.13</td>
<td>0.000</td>
</tr>
<tr>
<td>Early/Late Preference Scale</td>
<td>41 23:44 45.9</td>
<td>39 01:09 72.7</td>
<td>6.2**</td>
<td>1.40</td>
<td>0.000</td>
</tr>
<tr>
<td>Basic Language Morningness Scale</td>
<td>41 23:45 46.6</td>
<td>41 01:20 81.7</td>
<td>6.4**</td>
<td>1.44</td>
<td>0.000</td>
</tr>
<tr>
<td>Composite Scale</td>
<td>45 23:49 46.2</td>
<td>43 01:19 84.0</td>
<td>6.6**</td>
<td>1.45</td>
<td>0.000</td>
</tr>
<tr>
<td>Student Morningness-Eveningness Questionnaire</td>
<td>41 23:47 42.3</td>
<td>36 01:30 83.8</td>
<td>6.4**</td>
<td>1.53</td>
<td>0.000</td>
</tr>
<tr>
<td>Horne-O¨ stberg Reduced Scale</td>
<td>43 23:49 46.2</td>
<td>36 01:30 83.8</td>
<td>6.4**</td>
<td>1.53</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Notes: SD = standard deviation, $d$ = Cohen’s $d$, $t$ = $t$-value, $N$ = sample size. **$p < .01$ (Bonferroni correction).
seem to be in accordance with the objective (actigraphic) measures with respect to these sleep parameters.

Furthermore, the results from the \( t \)-tests showed that evening types had a significantly longer total sleep time on weekend nights than morning types in one of the self-report measures (the Composite Scale). Evening types did not have a significantly shorter total sleep time than morning types on weekdays, as found in previous studies (Giannotti et al., 2002; Taillard et al., 1999). Moreover, there was no significant correlation between any of the seven morningness measures and total sleep time on weekdays or weekend nights, which could be explained by the fact that the participants were not required to rise particularly early on a regular basis due to late or nonmandatory classes. In accordance with this, the evening types would not be expected to develop a significant sleep debt during the week. The longer total sleep time on weekend nights found among evening types compared with morning types in previous studies may indicate that evening types have a greater need for sleep than morning types (Taillard et al., 1999).

The results from the \( t \)-test showed that morning types had a significantly earlier nadir for activity than evening types in all self-report measures. In addition, the correlation coefficients between the morningness measures and the nadir for activity were significant and went in the expected direction for all seven measures. Hence, all of the instruments seem to be in accordance with the objective (actigraphic) measurements with respect to time for activity.

A complete novel aspect of the present study was its investigation of the relationship between ME questionnaires and intra-daily stability and inter-daily variability. The hypothesis that morning types have a significantly higher inter-daily stability than evening types with respect to physical activity was not confirmed.

The hypothesis that morning and evening types do not differ in intra-daily variability was confirmed for all seven self-report instruments that measured the ME dimension. Thus, morning types and evening types seem to show the same average variation in activity over adjacent time periods within a day. Even so, since our research hypothesis equals the null hypothesis, confirmation of this hypothesis may also be due to low power. Thus, this result should be interpreted with caution.

Overall, the results indicate that there are many similarities between the instruments in terms of their concordance with actual behavior regarding bed times, rise times, and nadir. Bed time, rise time, and the preferred time for performing demanding activities are the main aspects of the ME dimension, and these three parameters are well-covered by all seven instruments. All of the instruments are also similar in that they did not detect any differences between the groups in terms of inter-daily stability or intra-daily variability. Thus it may seem that the ME trait is not related to differences in these two activity-related variables, though more studies are needed in order to confirm or refute this. Overall, the seven instruments seem to have almost identical validity.

### Strengths and Limitations

This study utilized actigraphic data to validate self-report instruments which is an advantage since it avoids the common method bias (Fiske, 1982). To the best of our knowledge, this is the largest study according to sample size which explores the relationship between self-report instruments of the ME dimension and actigraphic data. Furthermore, no previous studies have included as many as seven different measures of the ME dimension. Finally, using students as participants has the advantage of the participants’ circadian rhythm being largely consistent with their preferred circadian rhythm since their rhythm is less constrained by external demands (Adan & Natale, 2002). One limitation of the present study is that because the actigraphy recordings were made for seven days, there were only two nights per subject from which the total sleep time for weekends could be calculated. A disadvantage of using actigraphy is that body movements during sleep are not distinguished from those during waking time. It should be noted that some of the scales had overlapping items, which obviously will influence the cross-validating data.

Several of the self-report instruments have defined cutoff scores which divide the participants into morning and evening type groups; these scores are often used in studies that explore the ME dimension. However, in our study, the groups were based on quartiles rather than the standard cutoff scores, which have also been utilized in previous studies.
(Randler & Frech, 2006). Moreover, one study that used cutoff scores compared evening and intermediate types, and excluded morning types due to the low number of participants in the group (Digdon, 2008). As it was desirable to have a close to even sample size of morning and evening types for each of the instruments, the use of quartiles rather than cutoff scores was regarded as being more suitable for this study. Even though quartiles were utilized, there were still some minor differences in the sample size of the groups. An additional argument for the use of quartiles was that the cutoff scores were made decades ago for some of the instruments, making them somewhat questionable. Lastly, cutoff scores were only developed for some and not all of the seven instruments utilized in this study, and it was desirable to use the same strategy for all the instruments.

**Proposals for Future Research**

This study contributes knowledge about the relationship between the ME dimension, as measured by several self-report instruments, and actual behavior as measured by actigraphy. The sample consisted of students, who at least in some respects are different from the general adult population, so it is recommended that future studies also include other groups of participants. Due to the cross-sectional design of this study, it is not possible to make inferences about causal relationships between study variables. In order to be able to make such inferences, future research in this field should also include longitudinal studies, as such studies could potentially provide information about the degree to which the ME trait is influenced by other personality traits as well as by sleep habits and lifestyle factors. Such studies could then provide information about what makes people morning-oriented or evening-oriented. In addition, longitudinal studies may explore the degree to which the ME trait itself influences other aspects of psychological functioning. Although evening types have been found to report more psychological and psychosomatic disturbances than morning types, as well as more difficulty coping with external demands (Mecacci & Rocchetti, 1998), conclusions cannot be drawn about causality due to the design of the studies. Learning more about causal relationships, and about what morning and evening orientation predict in terms of function from both a short- and long-term perspective, would enable interventions aimed at subjects at risk to be made.

Future research should also use larger samples to explore the factor structure of items from several ME inventories. Cross-cultural differences in the ME dimension should be further explored (Caci et al., 2002), and it would be of particular interest to investigate whether scores on measures of the ME dimension are related to the distribution and availability of modern devices such as the Internet, mobile phones, game consoles, and so forth.

**References**


Received May 23, 2009
Accepted February 1, 2011
Published online September 2, 2011

About the authors

Eirunn Thun is a psychologist with sleep and shift work as her main research interests.

Bjørn Bjorvatn, MD, PhD, is Professor of Medicine at the University of Bergen. His main research interest comprises sleep and sleep disorders. He is Director of the Norwegian Competence Center for Sleep Disorders.

Therese Osland, MD is currently working as a research fellow at the University of Bergen. Her main research interest is clock genes.

Vidar Martín Steen, MD, PhD, is Professor at the University of Bergen. His main research interests comprise medical genetics and molecular medicine.

Børge Sivertsen, PhD, has his main research affiliation with the Norwegian Institute of Public Health. His main research interest concerns the epidemiology of sleep difficulties and sleep disorders.

Torill Johansen has a bachelor’s degree in psychology and is currently working on a master’s thesis in psychology.

Tom Halvor Lilleholt has a bachelor’s degree in psychology and is currently working on a master’s thesis in psychology.

Idalill Udnes has a bachelor’s degree in psychology and is currently working on a master’s thesis in psychology.

Inger Hilde Nordhus, PhD, is Professor of Psychology at the University of Bergen. Her main research interests comprise gerontology and sleep disorders.

Ståle Pallesen, PhD, is Professor of Psychology at the University of Bergen. His main research interests comprise sleep disorders and nonchemical addictions.

Ståle Pallesen

Department of Psychosocial Science
University of Bergen
Christiesgatan12
5015 Bergen
Norway
E-mail staale.pallesen@psysp.uib.no