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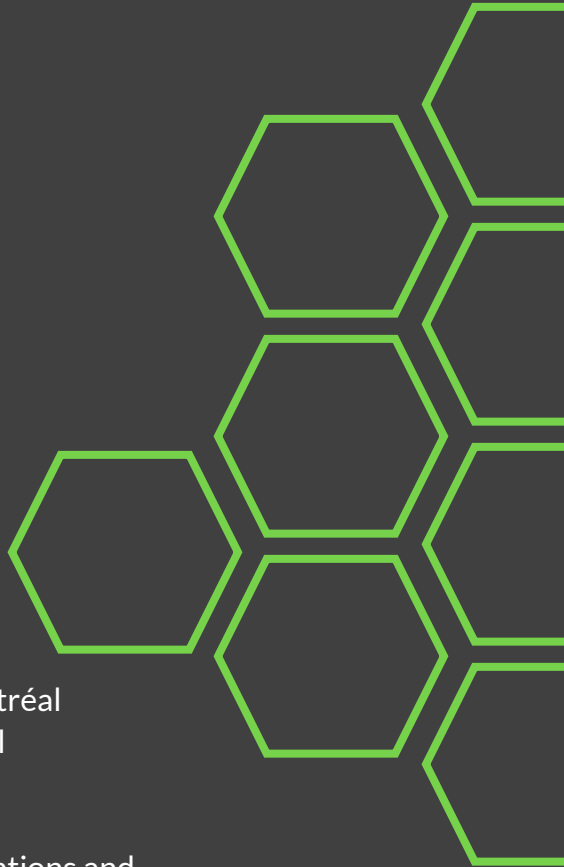
INTERACT FLASH REVIEW

MEASURING WELL-BEING
WITH ECOLOGICAL
MOMENTARY ASSESSMENT

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Question

The purpose of this review is to identify and assess measures of **well-being** to be administered through **Ecological Momentary Assessment (EMA)**. EMA refers to an ambulatory data collection method with measures obtained in real time, in a real-life context, and which are repeated (Shiffman, Stone, & Hufford, 2008). We assess the tools and methods which have been used to measure well-being through EMA, and make recommendations for INTERACT, specifically regarding:

- 1) the choice of questions/items and;
- 2) the administration modalities.

We also report on documented response rates of EMA among certain subgroups of the population, such as older adults, racial minorities or people with mental health challenges.

Well-being

Well-being is a fundamental resource for individual's health and is often conceptualized along hedonic and eudaimonic approaches (Deci & Ryan, 2008). Hedonic well-being generally refers to **affective states**, defined by one's evaluation of their ongoing experience, and expressed in the form of positive and negative emotions, moods or feelings (Diener, Scollon, Lucas, Napa Scollon, & Lucas, 2009). It is also thought of in terms of **cognitive states**, as an overall evaluation of, or general attitude to, one's life (*life satisfaction*) (Deci & Ryan, 2008). Some researchers combine these two components to create a composite measure of hedonic well-being also called "*subjective well-being*", which focuses on short-term happiness (Angner, 2010). Eudaimonic well-being is a broader concept that includes several characteristics of psychological and social functioning (Ryan, Huta, & Deci, 2008). Interpretations of eudaimonic well-being can differ. Some refer to it in terms of how we conduct our lives, the capacity for self-realization and personal growth (Ryan et al., 2008), others focus more on the cognitive and affective functions that underlie functioning and motivation to achieve a purpose in life or the ability to meet basic needs such as autonomy (Sheldon, 2018; Sonnentag, 2015).

The affective and cognitive states that make up hedonic well-being seem to be more susceptible to short-term variations, whereas eudaimonic well-being may refer to dimensions that are more stable in time. Research has shown that hedonic dimensions of well-being are associated with the conditions of one's immediate environment, including social interactions and observed peer behavior (Sonnentag, 2015). Hedonic dimensions of



well-being are hence possibly more context-sensitive than eudaimonic dimensions and could vary throughout the day. This is important to acknowledge if one aims to capture temporal variations in well-being through EMA at relatively short time scales, such as within-day. While eudaimonic well-being seem to represent psychological dimensions that are a priori more stable in time (Sonnentag, 2015), there is a lack of studies that have examined how they may vary through time.

INTERACT seeks to measure both hedonic and eudaimonic conceptions of well-being. The main survey that cohort participants complete online, administered every two years, contains three questionnaires on well-being. Two are meant to capture hedonic well-being: the Personal Wellbeing Index (The International Well Being Group, 2013), and the Subjective Happiness Scale (Lyubomirsky & Lepper, 1999), while the third - the Mental Health Continuum (Keyes, 2002)- captures eudaimonic well-being.

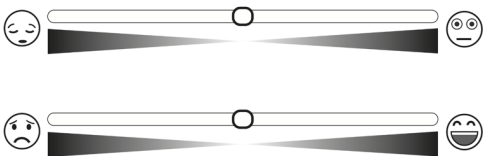
EMA is particularly interesting for the measurement of hedonic well-being (Liu, Xie, & Lou, 2019), given that it can capture self-reported data 'in the moment' via a smartphone application. EMA may reduce recall bias by asking questions about the present moment (e.g. 'At this moment, I feel...'). The possibility for repeated assessments allow to capture potential daily variations in affective states that could be linked to environmental conditions or actual behaviors (Shiffman et al., 2008). Because EMA responses can also be tagged with GPS coordinates, it is possible to link momentary affects with environmental conditions obtained from existing GIS layers (Shiffman et al., 2008).

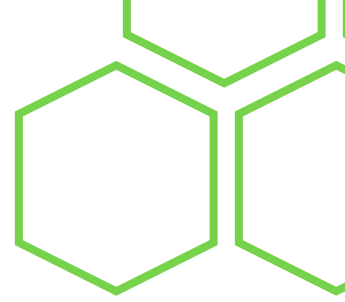
The INTERACT study aims to better understand the multiple pathways linking socio-economic and gender status, exposure to built environments and urban interventions, daily mobility, physical activity, social interaction, and well-being. To inform this, we review the methodologies adopted to capture hedonic well-being through EMA in previous studies and assess strengths and weaknesses of each approach based on their potential applicability to INTERACT. We specifically assess 1) the questions or items used and the dimensions of hedonic well-being they capture and 2) the protocol of administration - mainly EMA frequency and duration. The purpose was not to systematically review the literature on EMA and well-being, but rather gain a general knowledge of the different methodologies implemented. We evaluate a methodology's relevance to INTERACT by looking at its ability to capture daily variations of multiple dimensions of hedonic well-being as well as its feasibility and acceptability within different population groups.

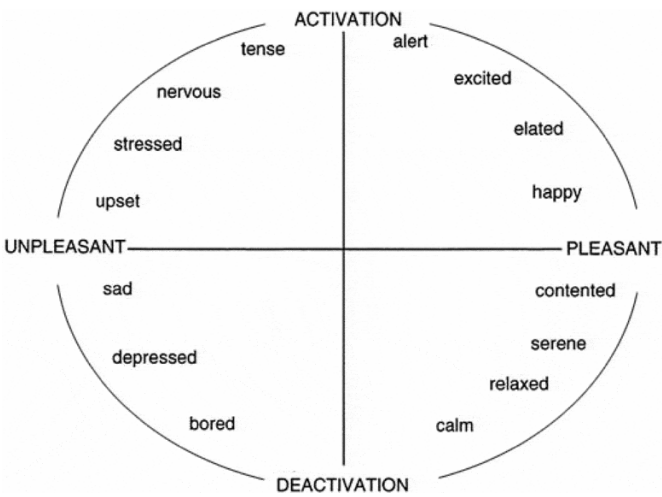
For this flash review we did a combination of searches using the following keywords: "ecological momentary assessment", AND ("affect", OR "happiness", OR "mood", OR "well-

being") in PubMed and Google Scholar and used a snowball approach to find other relevant articles. We selected studies that assessed daily or intra-day variations of well-being, affect or mood using an EMA method through a smartphone application or a similar mobile device.

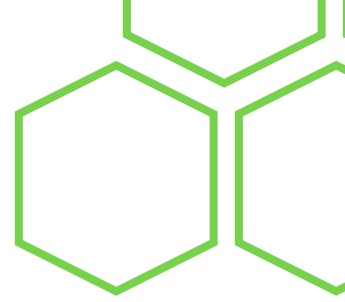
Table 1. Questionnaires or Items used in EMA Studies to Measure Affective Dimensions of Hedonic Well-Being

| Reference - Questionnaire | Description | INTERACT applicability |
|---|--|--|
| <p>(Betella & Verschure, 2016)</p> <p>Affective Slider (AS)</p> <p>2 questions (pictograms)</p> | <p>The “Affective Slider” is a digital scale for the self-assessment of emotion composed of two separate slider controls (or “sliders”) that measure pleasure and arousal. Underneath each slider two isosceles triangles are placed (symmetrically mirrored from the top most vertex) that serve as a visual cue for intensity.</p> <p>Empirical validation of the scale by systematic comparison with the Self-Assessment Manikin (SAM). Spearman correlation between AS and SAM of 0.852 for pleasure dimension and 0.860 for arousal dimension (N= 309 participants).</p>  <p><i>Figure 1: The “Affective Slider”, a digital self-reporting tool composed of two sliders that measure arousal (top) and pleasure (bottom) on a continuous scale (Betella & Verschure, 2016).</i></p> | <p>Simple to apply, does not require many written instructions</p> |



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| <p>(Posner, Russell, & Peterson, 2005) - Questionnaires based on the Circumplex Model of Affect</p> <p>(4 to 7 questions)</p> | <p>Many variants can be found but most measure 2 dimensions of affective states suggested by the Circumplex Model of Affect (Posner et al., 2005):</p> <p>Valence: pleasure vs displeasure</p> <p>Arousal: activation vs deactivation</p> <p>Positive affect: activated pleasure (happy or cheerful) and deactivated pleasure (calm or relaxed).</p> <p>Negative affect: activated displeasure (frustrated or angry) and deactivated displeasure (sad or depressed).</p> <p>Around 3 to 4 questions for each positive and negative affect.</p> <p>Several authors have developed their own scale of affect measurement based on the Circumplex Model of Affect (e.g.: Dunton, Liao, Huh, & Leventhal, 2015; N= 116 adults). These scales vary in number of items and methods of use and do not appear to have been empirically validated.</p>  | <p>Acceptable length of questionnaire</p> |
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| | <p><i>Figure 2: Circumplex Model of Affect with the horizontal axis representing valence and the vertical axis representing arousal (Posner, Russell, & Peterson, 2005)</i></p> | |
| <p>(Bradley & Lang, 1994) - Self-Assessment Manikin 3 questions (pictograms)</p> | <p>Paper instrument developed in 1994 to measure momentary affect using a nonverbal method with satisfactory factorial validity (N= 78 adults). Measures the dimensions of pleasure, arousal and dominance using a series of graphic abstract characters horizontally arranged according to a 9-points scale (even though 5-, 7-points and other variants exist). Pleasure ranges from a frowning to a smiling figure, arousal spans from a sleepy to a widely awake figure showing an incremental explosion at the center, while dominance ranges from a very small to a very large character.</p> <p><i>Figure 3: The Self-Assessment Manikin used to rate the affective dimensions of valence (top row), arousal (middle row), and dominance (bottom row) (Bradley & Lang, 1994).</i></p> | <p>Simple to apply, does not require many written instructions</p> |
| <p>(Wilhelm & Schoebi, 2007)- Short Mood Scale</p> | <p>Shortened version of the German Multidimensional Mood Questionnaire (MDMQ) (Steyer, Schwenkmezger, Motz, & Eid, 1994), explicitly developed for use of ambulatory methods. The MDMQ has been validated in German and in English and both versions showed high reliability (internal</p> | <p>Acceptable length of questionnaire Empirically validated for</p> |

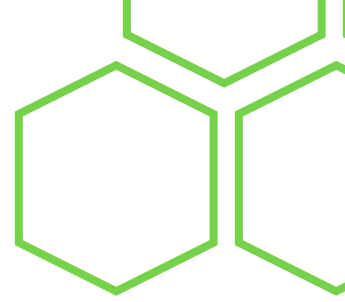


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| <p>(6 questions)</p> | <p>consistency coefficients between 0.69 and 0.86) (Steyer, Schwenkmezger, Notz, & Eid, 1997).</p> <p>This short version measures three dimensions of affective states with two bipolar scale for each dimension:</p> <p>Valence: unwell vs. well, discontent vs. content,</p> <p>Calmness: relaxed vs. tense, calm vs. agitated,</p> <p>Energetic arousal: tired vs. awake, without energy vs. full of energy.</p> <p>Each bipolar scale has 7 points with endpoints 0 and 6 labeled “very”.</p> <p>According to the authors, the repeated measures are highly sensitive to variations of affect and the scale allows reliable measure of well-being and levels of energy.</p> <p>Internal consistency coefficient varied from 0.70 to 0.88 for the within-person reliability and from 0.90 to 0.95 for the between-person reliability (Wilhelm & Schoebi, 2007; N=187 adults).</p> | <p>the repeated measure of momentary affect</p> <p>Measures 3 dimensions of affect</p> |
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Table 2. Review of the Administration Modalities of EMA Questionnaires to assess Well-Being

| Reference – Questionnaire | Details on the administration modalities of the EMA method | Key points regarding the administration modalities |
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| (Wilhelm & Schoebi, 2007)– Short Mood Scale | N= 187 adults Aged 19-36 years (Mean: 25.6 +/- 3.2) 4567 data points (range from 6 to 44 answers per participant). Most missing | 3 dimensions (valence, calmness & energetic arousal), 2 bipolar questions per dimension |

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| | <p>observations were caused by technical problems.</p> <p>4 EMA surveys/day randomized in +/- 20 min windows around 11:00 a.m., 2:30 a.m., 6:00 p.m. and 9:30 p.m. during 7 consecutive days.</p> <p>Scale had 7 steps: endpoints 0 and 6 were associated with the label "very". Answers were given by moving a slider from the start position 0, at the left end of a scale, to the position which corresponded best to the current state.</p> <p>This study evaluates the structural validity, the sensitivity to change and the reliability of the short scale.</p> | <p>Prompt: "At this moment I feel..."</p> <p>Using a personal digital assistant, the average compliance rate per participant was 87.5%.</p> |
| <p>(Bossmann, Kanning, Koudela-Hamila, Hey, & Ebner-Priemer, 2013) - Short Mood Scale</p> | <p>N= 62 students</p> <p>Aged 19-30 years (Mean = 21.4 +/- 1.8).</p> <p>Study conducted over the course of 1 day. Electronic diary items were completed via smartphones. The students activated their electronic diaries after waking up, and the measurements were repeated each full hour thereafter.</p> <p>Total of 807 data points.</p> <p>6-point scale (0 to 5). Answers for each bipolar item were provided by moving from the point 0 on the left labeled with i.e. "discontent" to the point 5 on the right labeled i.e. "content".</p> | <p>3 dimensions (valence, calmness & energetic arousal), 2 bipolar questions per dimension</p> <p>Electronic diary completed on a smartphone every hour after waking up for 1 day; average of 10.5 assessments/participant</p> <p>6-point scale, does not contain a mean value, forcing directionality</p> |
| <p>(Dunton, Liao, Huh, & Leventhal, 2015)-</p> | <p>N= 116 adults</p> <p>Aged 27-73 years (Mean = 40.5 +/- 9.5)</p> | <p>Using a mobile phone, the average compliance rate per participant was 83% across all 3 waves.</p> |



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| <p>Questionnaire based on the circumplex model of affect:</p> <p>3 items measuring positive affect and 4 items measuring negative affect (7 total).</p> | <p>Between 2068 to 2281 data points (range of 10 to 96 per participant).</p> <p>Randomly prompted EMA surveys within 8 programmed windows of time per day between 6:30 a.m. and 10 p.m., for 4 days across 3 waves per year.</p> <p>5-point scale: not at all, a little, moderately, quite a bit, extremely.</p> | |
| <p>(Schlee et al., 2016)–</p> <p>Self-Assessment Manikin (SAM)</p> | <p>N= 592 had completed at least one EMA survey</p> <p>Average age: 44.1 years</p> <p>The authors used the SAM as part of a study on the conceptual and technical framework for the measurement and monitoring of tinnitus symptoms using a web-based and a mobile application platform. The SAM was included in an 8-item questionnaire.</p> <p>The surveys were sent at random time-points between 8:00 am and 10:00 pm and participants were allowed to adjust the EMA schedule of the day as needed. (Maximum of 12 surveys per day).</p> | <p>Very short survey measuring affect with 2 nonverbal items (SAM).</p> <p>The authors do not report results regarding compliance rate of EMA participants. The affect measure was not a variable of interest in this work.</p> |
| <p>(Kanning & Hansen, 2017) -</p> <p>Short Mood Scale</p> | <p>N= 68 adults</p> <p>Aged 50+ years (Mean= 60.1 +/- 7.1)</p> <p>1311 data points (Mean= 19.3 e-diary entries/subject).</p> <p>3 consecutive days, between 8:00 a.m. and 9:00 p.m. with a time interval of</p> | <p>Short Mood Scale can be a quick way to measure 3 dimensions of affective states.</p> <p>Prompt: “At this moment, I feel...”</p> |

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| | <p>minimum 40 minutes and maximum 100 minutes between the assessments.</p> <p>EMAs triggered based on activity/inactivity thresholds: 220 milli-g and 10 milli-g measured with accelerometer.</p> <p>6-point scale (0 to 5). Answers for each bipolar item were provided by moving from the point 0 on the left labeled with i.e. “discontent” to the point 5 on the right labeled i.e. “content”.</p> | <p>Using a smartphone, the compliance rate of EMA participants was over 90%.</p> |
| <p>(Liao, Chou, Huh, Leventhal, & Dunton, 2017) - Questionnaire based on the circumplex model of affect:</p> <p>(5 items total)</p> | <p>N= 82 adults</p> <p>Average age: 39.8 years</p> <p>Randomly timed EMA survey questions, up to 8 times per day for 4 consecutive days. Majority of participants answered 1 or 2 EMA survey on affective states across the 4 days of data collection (19 had more than 2 EMA entries)</p> <p>3 waves of data separated by 6 months.</p> <p>2 items to measure positive affect: activated (happy, cheerful) and deactivated (calm or relaxed) pleasure.</p> <p>2 items to measure negative affect: activated (anxious, stressed) and deactivated (depressed, angry) displeasure.</p> <p>1 item assessing feeling of energy and one assessing feeling of fatigue.</p> <p>5-point response scale: 1= not at all, 2= a little, 3= moderately, 4= quite a bit & 5= extremely</p> | <p>Participants were asked about their affective states “just before the beep went off”.</p> <p>Using a mobile phone, the average compliance rate of EMA participants was 82%.</p> |



Studies on EMA within Subgroups of the Population

The studies presented in Table 2 were mainly conducted among groups of adults aged 19 years or over, representative of the general population. When reported, the average compliance rate ranged from 82% to more than 90%. Some authors have assessed the perception and feasibility of smartphone-based EMA methods among elderly (Cain, Depp, & Jeste, 2009), racial minorities (Fritz, Tarraf, Saleh, & Cutchin, 2017), and adults living with mental disorders (Ramsey, Wetherell, Depp, Dixon, & Lenze, 2016). In a review of studies using EMA methods with elderly, Cain and colleagues (2009) found that among the studies reporting the compliance rate of EMA participants, almost all reported an average rate over 80%. One study reported a lower compliance rate (73%) due to a very demanding evaluation frequency. Fritz and colleagues (2017) demonstrated the feasibility of using a smartphone-based EMA method with African-Americans aged 55 or older, living in neighborhoods with increased social or environmental stressors. Although the authors do not report specific compliance rates, they concluded that compliance with the EMA protocol in this population was satisfactory. They found that the small proportion of missing data was not associated with specific characteristics of participants, but rather distributed randomly. Furthermore, in a study on the feasibility and perception of the method among older adults living with anxiety and depression (Ramsey et al., 2016), the response rates and the reported reasons for non-responding to EMA were similar to those observed in the general population. The main reasons given for lack of compliance were being busy, not having the smartphone on oneself at the time of the prompt, not hearing the alert and having technical problems or user's difficulties. In sum, the feasibility, satisfaction, and comfort regarding EMA methods with elderly and adults living with emotional or cognitive difficulties seem similar to the rates reported in general population (Cain et al., 2009; Ramsey et al., 2016). These studies showed satisfying results in terms of participant compliance rate and method acceptability within different subgroups of the population.

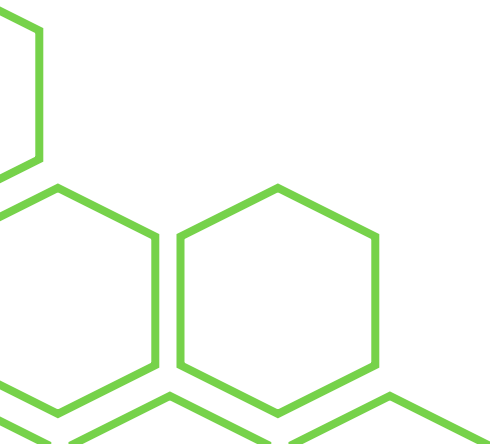
Recommendations

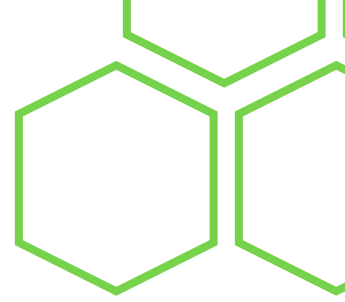
Based on this flash review, we recommend using the Short Mood Scale for INTERACT, since it has been used successfully in previous studies (Bossmann et al., 2013; Kanning & Hansen, 2017; Wilhelm & Schoebi, 2007) measuring three dimensions of affect, while remaining short, thereby limiting the burden for participants.

We recommend using the prompt: “*At this moment, I feel...*”, as it provides a clear indication of the moment we are asking the participants to report on.

| Short Mood Scale | French version of the Short Mood Scale |
|--|---|
| <i>To measure valence</i> | <i>valence</i> |
| <ul style="list-style-type: none"> • Unwell / Well • Content / Discontent | <ul style="list-style-type: none"> • Mal/ Bien • Content(e)/Mécontent(e) |
| <i>To measure calmness</i> | <i>calme</i> |
| <ul style="list-style-type: none"> • Relaxed / Tense • Agitated / Calm | <ul style="list-style-type: none"> • Détendu(e)/Tendu(e) • Agité(e)/Calme |
| <i>To measure energetic arousal</i> | <i>énergie</i> |
| <ul style="list-style-type: none"> • Tired / Awake • Full of energy / Without energy | <ul style="list-style-type: none"> • Fatigué(e)/Alerte • Plein(e) d'énergie/ Sans énergie |

The Short Mood Scale is a short version of the Multidimensional Mood Questionnaire (Steyer et al., 1994). Its use with an EMA method has been empirically evaluated and demonstrated good validity and fidelity properties (Wilhelm & Schoebi, 2007). The six-item Short Mood Scale measures the basic affective states of **valence**, **calmness**, and **energetic arousal** using two bipolar items for each scale. It allows a distinction between calmness and energetic arousal that is not possible with questionnaires based on the Circumplex Model of Affect (Posner et al., 2005; Wilhelm & Schoebi, 2007). Measuring these three dimensions will give a broader understanding of the dynamic affective components of participants' hedonic well-being.





Summary Table of Recommendations for EMA for INTERACT

| Recommended measure(s)/method(s) | Justification | References |
|---|--|---|
| Use the prompt: “At this moment, I feel...” | Clear indication of the moment we are asking the participants to report on (even if they see the notification late) | (Kanning & Hansen, 2017; Wilhelm & Schoebi, 2007) |
| Consecutive days of data collection | All studies report consecutive days of data collection (unless environmental or PA triggered EMA) | (Kanning & Hansen, 2017) |
| Collect EMA data for 4-10 days | Based on the reviewed literature, 4 days is the minimum duration required to capture intra-day variations. More than 10 days of repeated measures could result in lower compliance. | (Dunton et al., 2015; Ramsey et al., 2016) |
| Ask EMA 3-4 times a day at random times. | Allows to measure intra and inter day variations. A frequency of measurement between 3 and 4 times a day is reasonably demanding for participants and minimizes the rate of non-compliance with the protocol. The randomization of the prompt across windows of time during the day allows to measure intra-daily variations by assuring a certain amount of time between two measurement. It also prevents participants from expecting the prompt, which could influence their responses. | (Ramsey et al., 2016; Wilhelm & Schoebi, 2007) |
| Use 6-point scale. | We recommend a 6-point scale describing the intensity to which participants are experiencing the affect at the present moment. | (Bossmann et al., 2013; Fritz et al., 2017; Kanning & Hansen, 2017) |

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| | There should not be any 'default' position of the cursor on the scale, in the sense that participants need to touch the cursor to validate their answers and go to next question. | |
| Report compliance | Compliance was not systematically reported in studies using EMA. We recommend providing detailed information on compliance in all results sections of papers analysing such data. | |

Acknowledgements

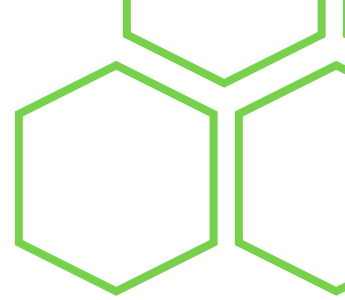
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