

Measuring Mood: Considerations and Innovations for Nutrition Science

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Abstract

There is growing evidence that nutritional factors such as macro- and micronutrients, fruits and vegetables, dietary patterns, and supplements are implicated in mood. The goal of this chapter is to review a range of traditional and innovative tools for assessing mood in relation to nutrition. We start by defining mood as a positive or negative emotional state of varying intensity that changes in response to life's circumstances and then discuss psychometrically-validated questionnaires that measure singular moods (e.g., depression) and multiple types of moods (e.g., sadness, anxiety, anger, vitality). We review questionnaires that also measure positive mood (e.g., calmness, happiness, vitality) and suggest that researchers expand their toolkit to include a broader range of well-being measures (happiness, life satisfaction, and eudaimonia – positive mood associated with purpose, engagement, and meaning). We review innovative methodological and technological components of real-time measures of moods using daily diaries and experience sampling methods and ecological momentary assessment which measure moods as they occur on a moment-by-moment or day-by-day basis for example through the use of smartphones. We

end by a recommendation to integrate more technologically advanced platforms and an emphasis on incorporating a range of ambulatory methods and sampling strategies. These real-time approaches mitigate memory biases that can occur when people reflect on their mood over the last week or “in general” as with standard questionnaire timeframes. As technology develops, real-time assessment will continue to offer an ecologically valid way of assessing the food and mood connection as it occurs in daily life, giving us new perspectives.

Measuring Mood: Considerations and Innovations for Nutrition Science

There is growing research into the role of nutritional factors in mental health, and in particular, the effect of diet on mood. A range of dietary factors have been linked to poorer mood including traditional western diets, sodas, snacks, chocolate, lower fruit and vegetable consumption (e.g., Rahe, Unrath & Bergers, 2014; Jacka et al., 2010) and certain micronutrient deficits (e.g., Colangelo et al., 2014; Polak, Houghton, Reeder, Harper, & Conner, 2014; Yi et al., 2011; also see Rucklidge & Kaplan, 2013 for a review). But what is mood exactly? And, how can nutrition researchers measure it in a psychologically sophisticated way using validated questionnaires? In this chapter, we define mood and review a range of tools for measuring mood in nutrition research. We cover well-used self-report questionnaires such as the Center for Epidemiological Depression Scale (CES-D, Radloff, 1977) and the Profile of Mood States questionnaire (POMS, McNair, Lorr, & Droppelman, 1971), and other tools commonly used in the nutrition literature (e.g., General Health Questionnaire-12, GHQ-12; Goldberg & Williams, 1991; Positive and Negative Activation Schedule, PANAS, Watson, Clark, & Tellegen, 1988). We discuss the strengths and weaknesses of these well-used measures from a psychological perspective and suggest additional tools to measure positive states of well-being, such as the Psychological Wellbeing Scale (PWB, Ryff & Keyes, 1995), which are relatively under-utilized in nutrition research. We then introduce novel ways of tracking mood in real time using ecological momentary

assessment or experience sampling methods on mobile phones and via internet surveys. Our goal is to provide practical guidelines for choosing the right mood measure for the research question to be addressed.

Defining Mood

In the field of psychology, mood refers to a positive or negative emotional state of varying intensity that changes in response to life's circumstances. Moods are often undifferentiated, slower to change, and 'object-less' in that people may not know the cause or source of the mood (Russell, 2003). For example, a person may feel "down" or "blue," which could last for days or even weeks in the case of depression, and a person may not know why he or she feels this way. By contrast, emotion refers to an acute, specific feeling state felt in response to an event (Russell, 2003). For example, a person might feel the rush of anger in response to a challenging situation, but this feeling dissipates. Whereas emotion refers to prototypical reactionary states such as anger, sadness, fear, disgust, happiness, or surprise, moods often reflect feelings of valence (feeling good / bad) and activation (feeling sleepy / awake) (Barrett & Russell, 1999). These two dimensions have been discovered through principal components analysis of multiple mood reports, which have yielded a "circumplex" reflecting four broad types of moods: positive high activation (enthusiastic, excited, cheerful), positive low activation (calm, relaxed, peaceful), negative high activation (anxious, hostile, stressed), and negative low activation (sad, depressed, dejected) as shown in Figure 1 (Barrett & Russell, 1999).

A good way to think about mood measures is to understand which parts of the circumplex they are capturing. Some questionnaires target specific quadrants in the circumplex such as depression (representing a low activation negative mood) or vitality (a high activation positive mood), whereas others target the broader dimensions of positive and negative affect (PA/NA).

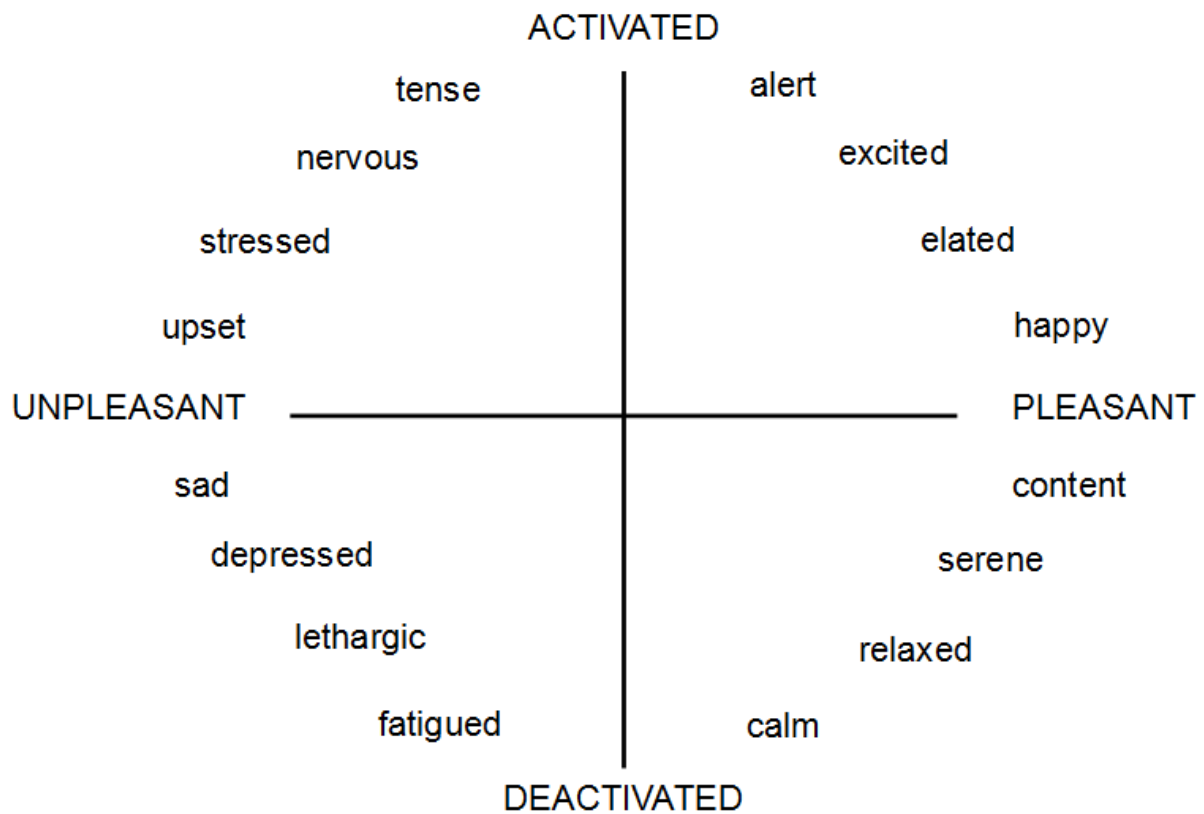


Figure 1. A circumplex model of mood reflecting differences in valence (positivity / negativity) and activation (high energy / low energy). Adapted from Barrett and Russell, 1999.

Common Tools for Measuring Mood in Nutrition Science

In this section, we review several common mood measures used in nutrition research, focusing on questionnaire measures of depression, anxiety, and multiple moods. We also introduce measures of positive mood and psychological well-being that may provide good counterpoint to the nearly exclusive focus on negative mood in nutrition research. For each section, we give recommendations for the use of these measures.

Measuring Depression

One of the most popular measures of depressed mood is the 20-item Center for Epidemiologic Studies - Depression Scale (CES-D; Radloff, 1977). The CES-D is made up of

20 items that are answered on a Likert scale from zero (“rarely or none of the time” i.e., less than 1 day) to three (“most or all of the time” i.e., 5 to 7 days). Items are answered with reference to the past week. Example items include “*I thought my life had been a failure*” and “*I had crying spells*”. After reverse-scoring of four items (items 8, 12, 16, and 20) all items are summed to give a total score within the range of zero to sixty. A cut-off score of ≥ 16 is recommended to indicate those who are at risk of depression, although higher cut-off scores of ≥ 19 (e.g., Yi et al., 2011) and ≥ 27 (e.g., Colangelo et al., 2014) have also been used. However, this measure should not be used as a diagnostic tool per se. The CES-D was designed for use in community populations and focuses largely on the affective symptoms of depression. Nutrition research using the CES-D has reported associations between higher depressive symptoms and higher selenium exposure (Colangelo et al., 2014), lower serum ferritin levels (Yi et al., 2011), and lower vitamin D levels (Polak et al., 2014); and associations between lower depressive symptoms and consumption of whole foods (Akbaraly et al., 2009) and higher intake of fruit, vegetables, and fibre and lower intake of *transfat* (Akbaraly, Sabia, Shipley, Batty, & Kivimaki, 2013). Furthermore, it has been found that micronutrient supplementation (containing folic acid, iron, vitamin B12, and zinc) for 12 weeks results in decreases on the total CES-D score (Nguyen et al., 2009; see Rucklidge & Kaplan, 2013 for a review).

The Beck Depression Inventory (BDI) on the other hand, was designed for use in clinical populations to assess the severity of depression (original, Version II, and fast screen for medical patients, Beck, Ward, Mendelson, Mock & Erbaugh, 1961; Beck, Steer, & Brown, 1996; see also Richter, Werner, Heerlein, Kraus, & Sauer, 1998, for a review of its’ validity). The BDI-II (1996) is the most recent version of this measure; it contains 21-items based on the Diagnostic and Statistical Manual of Mental Disorders criteria of Major Depressive Disorder (4th ed.; DSM-IV; American Psychiatric Association, 1994) although

there were no changes to the symptomatology of Major Depressive Disorder from DSM-IV to DSM-5 (American Psychiatric Association, 2013). The BDI-II is completed with reference to the past two weeks. Items are answered on a Likert Scale from zero to three. Example items include “*Self-criticalness*” (0 = I don’t criticize or blame myself more than usual; 3 = I blame myself for everything bad that happens) and “*Worthlessness*” (0 = I do not feel worthless; 3 = I feel utterly worthless). Items are summed to give a total score, which is interpreted as minimal depression (0-13), mild depression (14-19), moderate depression (20-28), or severe depression (29-63). The BDI-II emphasizes the cognitive symptoms of depression, unlike the CES-D which emphasizes more affective symptoms. Studies using various versions of the BDI have reported associations between more depressive symptoms and lower serum ferritin levels (Vahdat Shariatpanaahi, Vahdat Shariatpanaahi, Moshtaaghi, Shahbaazi, & Abadi, 2007), and infrequent fish consumption (Tanskanen et al., 2001).

For research in specific populations such as the elderly or pregnant women, the Geriatric Depression Scale and the Edinburgh Postnatal Depression Scale have been used respectively. The Geriatric Depression Scale (GDS; Yesavage et al., 1983) contains 30 items and is answered on a Yes/No scale. Items include “*Do you feel pretty worthless the way you are now?*” and “*Do you feel that your life is empty?*”. Responses are summed and the total score is then used to indicate likely depression, a cut-off score of ≥ 11 is recommended. The GDS has been used to examine links between increased depressive symptoms and lower selenium exposure (Gao et al., 2012; Johnson et al., 2013), and lower dietary intake of vitamin A, riboflavin, vegetables, and fibre (Woo et al., 2006).

The Edinburgh Postnatal Depression Scale (EPDS; Cox, Holden & Sagovsky, 1987) contains 10 items and is designed to screen for postpartum depression in women who have recently given birth. As a screen for postpartum depression, the EPDS should be administered within 8-weeks of giving birth; although it has also been validated as a major depression

screening tool during pregnancy (Murray & Cox, 1990). Items are answered with respect to the past week; examples of the items include “I have blamed myself unnecessarily when things went wrong” and “I have felt sad or miserable”. Responses are scored zero to three and scores are then summed. However, the utility of the EPDS as a screening tool has been criticised due to the wide variation in sensitivity and specificity (Gibson, McKenzie-McHarg, Shakespeare, Price, & Gray, 2009). A cut-off score of 13 or more is recommended as indicating probable postpartum depression (Cox et al., 1987; Matthey, Henshaw, Elliott, & Barnett, 2006), whereas a cut-off score of 15 or more is recommended as indicating probable antepartum depression (Murray & Cox, 1990). Researchers using the EPDS have reported that selenium supplementation (Mokhber et al., 2011) and iron supplementation (Beard et al., 2005) significantly reduced postpartum depression levels.

The Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983) was designed as a screening tool for anxiety and depression in general medical outpatients. Given that the measure was designed for those who are likely to have physical health complaints, the authors tried to include items that did not assess somatic symptoms of anxiety or depression. This measure contains 14 items that are answered on a Likert scale from zero to three. Seven items assess depression and seven items assess anxiety. Example depression items include “*I felt cheerful*” and “*I look forward with enjoyment to things*” (both reverse scored). A cut-off score of eight on each subscale is recommended to indicate potential cases of depression and anxiety (Bjelland, Dahl, Tangen Haug, & Neckelmann, 2002). Nutrition research using the HADS has reported associations between higher depression symptoms and lower magnesium intake (Jacka et al., 2009); and associations between lower depression levels and a more healthful diet (vegetables, fruits, cereals, non-processed meats etc.; Jacka, Mykletun, Berk, Bjelland, & Tell, 2011). HADS scores have also been shown to reduce significantly following micronutrient supplementation (containing selenium, vitamin C, and

folate) for eight weeks (Gosney, Hammond, Shenkin, & Allsup, 2008; also see Rucklidge & Kaplan, 2013 for a review).

Recommendation: Overall, for use in the general population, the CES-D or the HADS are recommended. These measures were designed for use in non-clinical populations and there is a large body of evidence supporting their use. Reviews of the observational studies of dietary intake and depressive symptoms indicate that the CES-D appears to be the most commonly used measure (Murakami & Sasaki, 2010; Lai et al., 2014). For clinical populations, the BDI-II is recommended. The BDI-II allows for comparison of groups according to depression severity (minimal, mild, moderate, and severe). However, the CES-D and the BDI-II, all contain items assessing appetite, concentration, and sleep difficulties. In populations where physical health conditions are common, or where nutritional deficiency is likely to produce physical symptoms, the HADS is recommended as this scale contains less somatically-laden items than the CES-D and the BDI-II. In elderly populations, the GDS is recommended as the language is more straightforward and the response format is simpler than other depression measures (Yes/No), although like the CES-D and the BDI-II, this measure contains items assessing the somatic symptoms of depression (sleep, concentration, and memory difficulties). For women who have recently given birth, the EPDS should be used as it is specifically designed for this population (women within 8 weeks of birth). The EPDS is also validated as a screening tool for depression in pregnant women.

Measuring Anxiety

The role of food in anxiety related mood is less established than the research on depressed mood. However, anxiety has been measured in several nutrition-related research areas, from experimental supplementation studies to cross-sectional population diet studies. The most common anxiety-specific mood measure is the State Trait Anxiety Inventory (STAI: Form Y; Spielberger, 1983). The STAI is a 40-item self-report scale that measures

both state (current feelings at this moment) and trait (general feelings of anxiety) factors of anxiety. Example items from the state anxiety scale include “*I am tense*”, or “*I am worried*”, whereas the trait anxiety subscale includes items such as “*I worry too much over something that really doesn't matter*”, or reverse-scored items such as “*I am a steady person*”. This measure is well established in diagnostic and clinical settings, as well as medical and research domains. Sound psychometric properties are reported including internal consistency coefficients ranging between 0.86 and 0.95 (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). The STAI has been used in nutritional and herbal supplementation research including a study that showed a reduction in anxiety in perimenopausal women with kava supplementation (Cagnacci et al., 2003), and a reduction in state anxiety in individuals following an essential amino acid - L-lysine and L-arginine supplement (Jezova, Makatsori, Smriga, Morinaga, & Duncko, 2005). The STAI was also used in an observational study of eating behaviours among high school students in an urban setting (Pastore, Fisher, & Friedman, 1996). Although no differences in state or trait anxiety were found between normal and overweight individuals, increased anxiety was associated with eating attitudes such as dieting and food preoccupation (Pastore et al., 1996). The STAI state anxiety measure has also been used to assess current levels of anxiety, concluding that the consumption of sweets and meat were associated with higher current feelings of anxiety (Yannakoulia et al., 2008).

The Hamilton Anxiety Rating Scale (HAM-A: Hamilton, 1959) is a clinician-rated instrument that is widely used in both clinical and research settings. This scale consists of 14 items measuring the severity of both psychological (mental agitation and psychological distress) and somatic anxiety symptoms (physical anxiety complaints; Hamilton, 1959). This scale includes domains such as tension and worry, and clinicians make observations rated on a scale of 0 (not present) to 4 (severe). Scores between 18 and 24 indicate mild to moderate severity, whereas 25 to 30 indicate moderate to severe anxiety symptoms (Hamilton, 1959).

A reduction in anxiety as indicated by the HAM-A has been shown in a number of plant-based supplement studies including: a four-week supplementation of *Ginkgo biloba*, an eight-week supplementation of chamomile, and a number of kava supplementation trials (for review see Sarris, McIntyre, & Camfield, 2013). While still commonly used, the HAM-A has been criticized in terms of its ability to distinguish between depressant and anxiolytic symptoms (Maier, Buller, Philipp, & Heuser, 1988), preventing it from being a measure of choice when trying to compare anxiety and depression. Furthermore, it has found to be only moderately associated with other strong predictors of anxiety such as the Beck Anxiety Inventory (BAI; Beck & Steer, 1993). The BAI is a 21-item self-report inventory which shows high internal consistency and test–retest reliability for measuring the severity of anxiety in psychiatric populations. The BAI discriminates anxious diagnostic groups well from non-anxious diagnostic groups (Beck, Epstein, Brown, & Steer, 1988), but has not been used in nutrition research due to its focus on clinical populations.

Anxiety can also be measured with the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983). As outlined in the previous section, the HADS is a well-established 14-item scale that has been widely used in medical outpatient and epidemiological research studies. In addition to the seven items that assess depression, seven items assess anxiety e.g., “*I feel tense or wound up*”, and, “*I get sudden feelings of panic*” (Zigmond & Snaith, 1983). The responses are recorded to on a Likert scale from zero to three. A cut-off score of 8 for anxiety provides specificity of 0.78 and sensitivity of 0.9 (Bjelland et al., 2002). In a cross-sectional study of middle age and elderly adults, a diet characterized largely by fruits and vegetables, whole grains, fish and non-processed meat (a ‘traditional’ diet), was associated with reduced likelihood of HADS anxiety scores in Norwegian women (Jacka et al., 2011). Conversely, a diet characterized by unhealthy and processed foods (a ‘Western’ diet), was associated with a greater risk of anxiety for both men

and women, as indicated by increased scores on the HADS (Jacka et al., 2011). In a study of adherence to a gluten free diet in a sample of individuals with Coeliac Disease (CD), a greater difficulty of adherence was associated with greater anxiety as measured by the HADS (Barrat, Leeds, & Sanders, 2011). Supplementation using a multivitamin (magnesium, zinc, and calcium) showed a reduction in anxiety as measured by the HADS after 28-day supplementation treatment (Carroll, Ring, Suter, & Willemsen, 2000). The HADS appears to be a reliable measure, efficient for use in research simultaneously measuring anxiety and depression symptomatology.

The General Health Questionnaire-12 (GHQ-12; Goldberg & Williams, 1991) is a common, brief self-report screening instrument for common mental disorders, which is widely used within general medical practice (Kalliath, O'Driscoll, & Brough, 2004). It is comprised of common mental health domains of depression, anxiety, somatic symptoms, and social withdrawal. The anxiety subscale includes items such as, "*Have you been getting scared and panicky for no good reason?*", and individuals respond using a Likert scale ranging from zero to three (Goldberg & Williams, 1991). This measure has been translated into over 38 different languages and its reliability coefficients have been reported between 0.78 and 0.95 (Jackson, 2007). While the GHQ-12 should not be used for predictive or diagnostic purposes (Jackson, 2007), it provides adequate screening of those identified as 'at risk' of developing psychological distress. In the current literature, the GHQ-12 has mainly been used in cross-sectional studies of diet quality. It was found that consumption of unhealthy Western diet patterns were generally associated with higher GHQ-12 scores, whereas the consumption of a traditional diet was generally associated with lower GHQ-12 scores (Jacka et al., 2010). Furthermore, reduced GHQ-12 scores were found in a study of the relationship between anxiety and polyunsaturated fatty acid (PUFA) intake and fish consumption (Jacka et al., 2012b), as well as decreased red meat consumption (Jacka et al.,

2012a). However, these studies used the GHQ-12 to assess to common mental disorders (anxiety and depression), reflecting an overall reduction in psychological distress, rather than anxiety specifically. The studies mentioned above used the GHQ-12 in conjunction with a ‘gold standard’ diagnostic interview to assess for specific anxiety related disorders. It is not recommended that the GHQ-12 be used in isolation to assess for anxiety in nutrition research, due to its brevity and broad approach to general mental health.

Lastly, the Structured Clinical Interview for the Diagnostic and Statistical Manual for Mental Disorders, Fourth Edition (Text Revised) (DSM-IV-TR), non-patient edition (SCID-I/NP: First, Spitzer, Gibbon & Williams, 2002) is a semi-structured diagnostic interview, considered a ‘gold standard’ assessment tool for anxiety (Sarris et al., 2013). It is the primary diagnostic instrument in assessing for anxiety related disorders including: panic, agoraphobia, social, specific, OCD, GAD, and anxiety due to substance or other medical disorder (First et al., 2002). For these diagnoses, symptoms are identified as ‘present’, ‘sub threshold’, or ‘absent’. This instrument is reasonably time consuming and is designed to be administered by a clinician or trained mental health specialist. However, it provides an indication of specific anxiety diagnoses rather than the presence of general anxiety symptomatology, making it a clinically relevant tool. The Structured Clinical Interview for DSM-5 is currently in the final stages of publication. A number of studies have found that a Western diet, characterized by unhealthy and processed food (Jacka et al., 2010; 2011; 2012b), and decreased red meat consumption in women (Jacka et al., 2012a) is associated with a higher prevalence of diagnosed anxiety disorders.

A number of physiological measures of anxiety have been used in nutritional research. Although these are not widely researched, they offer a promising route of objective anxiety indicators. For example, a significant improvement in vagal heart rate control was seen after a four week RCT of kava (Watkins, Connor, & Davidson, 2001). Similarly, an

RCT in healthy adults found that L-lysine supplementation over one week was associated with decreased hormonal stress response, as indicated by lower levels of salivary cortisol (Smriga et al., 2007).

Recommendation: Overall, for use in the general population, the STAI offers a sound anxiety measure when looking at anxiety in isolation. This measure has been well used in micronutrient supplement studies (Sarris et al., 2013; Lakhan & Vieira, 2010). This measure may be more useful for pre- and post-intervention comparison, but holds little predictive power in terms of diagnostic value. When research aims are clinically based, the SCI-DSM-IV is considered the ‘gold standard’ for diagnosis, and provides not only an indication of anxiety related symptomatology but can differentiate between types of anxiety disorders. It does not provide a score which can be statistically compared pre and post intervention; however, it can be used in research in combination with the STAI.

Measuring Multiple Aspects of Mood

Other questionnaires target multiple types of mood within the same questionnaire. For example, the Profile of Mood States (POMS; McNair et al., 1971) is a 65-item rating scale that yields a total mood index, plus a single index of positive mood (Vigor/Activity) and five indices of negative mood (Tension/Anxiety, Depression/Dejection, Anger/Hostility, Fatigue/Inertia, and Confusion/Bewilderment). Respondents use a unipolar scale to rate the extent to which they are experiencing or have experienced 65 affect states in the past week (e.g., *sad, tense, angry, energetic, weary, confused*) using a 5-point scale (0 = *not at all*, 4 = *extremely*). There are several other versions of the POMS including the revised POMS 2 that adds an additional scale (Friendliness) (Heuchert, & McNair, 2004), the youth version for adolescents ages 13 – 17 (POMS 2-Y), and also several shortened versions. The POMS, POMS 2 and their shortened variants are good measures because they capture a range of different negative moods and they include a measure of positive mood through the vigor

subscale (Vigor items: lively, active, energetic, cheerful, alert, full of pep, carefree, vigorous). However, the vigor subscale only measures higher activation positive mood, not lower activation positive mood, which be limiting if a nutritional intervention was designed to promote calmness. Nevertheless, growing evidence suggests that good nutrition may be associated with high activation positive mood states. Recent interventions studies have shown that fruit consumption and iron consumption increased scores on the Vigor subscale of the POMS (fruit, Carr, Bozonet, Pullar, & Vissers, 2013; iron McClung et al., 2009). Research using the POMS-Bipolar form (POMS-BI) has reported that selenium supplementation resulted in increased mood scores on four of the six subscales (Benton & Cook, 1991).

Another popular mood measure is the PANAS – the Positive and Negative Activation Schedule (previously called the Positive and Negative Affect Schedule; Watson et al., 1988). The PANAS is a 20-item scale that is commonly used to obtain separate measures of positive affect (PA) and negative affect (NA); however, in truth, this questionnaires yields measures of high positive activation and negative activation because all of the items capture high activation states e.g., *attentive, interested, alert, enthusiastic, excited, inspired, proud, determined, strong, and active* for PA and *distressed, upset, hostile, irritable, scared, afraid, ashamed, guilty, nervous, and jittery* for NA. There is also a shortened 10-item version of the PANAS that contains five items for PA and five items for NA (Mackinnon et al., 1999). Although this measure is very popular, researchers should be cautious when using it because neither the 20-item nor 10-item PANAS captures lower activation feelings of calmness, happiness or sadness. An extended version, the PANAS-X, is a 60-item scale available to measure more discrete feelings including some, but not all, lower level activation states (sadness, serenity, fatigue) in addition to the broader positive and negative activation states (Watson & Clark, 1994). The 20-item version of the PANAS has been used to examine links between mood and folate status (Williams et al., 2008), and zinc status (McConville et al.,

2005). The 10-item version of the PANAS has been used in research to demonstrate a link between a diet rich in Mediterranean foods (e.g., fruit, vegetables, whole grains) and higher PA and lower NA (Ford, Jaceldo-Siegl, Lee, Youngberg, & Tonstad, 2013).

Another approach to measuring mood is to use items reflecting all the combinations of valence and activation. For example, Polak and colleagues used an 18-item scale to measure PA and NA across three levels of activation (Polak, Conner, Reeder, Harper, & Houghton, in preparation). The scale is based on the affective circumplex (Barrett & Russell, 1999; Tugade, Conner, & Feldman Barrett, 2007) and includes a 9-item measure of positive affect (high activation: *energetic, enthusiastic, excited*; medium activation: *happy, cheerful, pleasant*; low activation: *calm, content, relaxed*), and a 9-item measure of negative affect (high activation: *hostile, angry, irritable*; medium activation: *nervous, anxious, tense*; low activation: *dejected, sad, unhappy*). This measure can be adapted to capture trait affect (“Typically, how happy do you feel?”) or state affect (“How happy do you feel today/right now?”). Questions are usually answered on a 5-point scale from 1 (not at all) to 5 (extremely) or from 0 (not at all) to 4 (extremely). This affective circumplex measure has not been validated, although it does show adequate internal consistency within the separate 9-item PA and NA scales (White, Horwath, & Conner, 2013). Because there are no norms, researchers might have difficulty linking this scale to previous research. However, we recommend a circumplex approach if there is a need to explicitly differentiate between high, medium, and low activation positive and negative mood states.

Verbal and visual analog measures of mood are also used in nutrient intervention studies. As a recent example, the effects of multivitamin supplementation on mood and well-being were assessed using several measures, including the 16-item Bond-Lader visual analogue scale (VAS) (Pipingas et al., 2013). This scale comprises 16, 100mm lines, anchored at both end with adjective pairs such as happy-sad. Participants mark their degree of

agreement between the adjectives based on their current subjective state, allowing fine discrimination along the 100mm scale (Bond & Lader, 1974). Scoring is calculated as the distance from the negative anchor. Analog scales have been successfully used in appetite control studies (e.g. Parker, Sturm, MacIntosh, Feinle, Horowitz, & Chapman, 2004), they show high reproducibility, power, and validity in appetite assessment in single meal studies (Flint, Raben, Blundell & Astrop, 2000), as well as good validity and reliability in mood disorders (Ahearn, 1997). Visual analogue scales may be particularly good to use with children because the questions are answered on a linear pictorial rather than a verbal scale (Miller & Ferris, 1993).

Recommendation: We recommend the POMS, POMS 2, and its variants to measure multiple mood states. The PANAS should only be used to measure high activation states. Otherwise, the PANAS-X or POMS would be the better choice. An underutilized option is the mood circumplex that captures both valence (negative–positive) and activation (high–medium–low) of mood states.

Beyond Negative Mood: Measuring Positive Mood and Psychological Well-Being

Measures of negative mood, depression, and anxiety are much more common in nutrition research than measures of happiness and life satisfaction. Yet there is emerging evidence that dietary factors may also play a role in these states of positive well-being. A recent study of over 80,000 British people found a strong link between consumption of fruit and vegetables with greater life satisfaction that was not accounted for by demographic or health factors (Blanchflower, Oswald, & Stewart-Brown, 2013). Contrary to common assumptions, these negative states of ill-being and positive states of well-being are not two sides of the same coin. Well-being reflects an optimal level of emotional experience and functioning, not simply the absence of depression or anxiety (Deci & Ryan, 2008). It is an

empirical question whether good nutrition increases well-being over and above any neutralizing effect on ill-being.

There are several psychometrically-validated measures of well-being that we recommend. Some measures target hedonic well-being, that is, whether people feel happy and are satisfied with their lives (Veenhoven, 2003). Measures of happiness include the first item in the Fordyce Happiness Measures (Fordyce, 1988), which asks people to answer “In general, how happy or unhappy do you usually feel?” on a scale from 0 (extremely unhappy) to 10 (extremely happy), and the 4-item Subjective Happiness Scale (SHS; Lyubomirsky & Lepper, 1999). Measures of life satisfaction include the OECD’s single item question of “Overall, how satisfied are you with your life as a whole these days?” answered from 0 “not at all satisfied” to 10 “completely satisfied” (OECD, 2013), the 1-item Cantril Scale (Cantril, 1965), which asks people to place themselves on a ladder where the bottom step (0) represents the “worst possible life for you” and the top step (10) is “the best possible life for you” (scores 7+ indicate thriving; scores ≤ 4 indicate suffering), and the 5-item Satisfaction with Life Scale (Pavot & Diener, 1993).

Other measures target eudaimonic well-being, that is, whether people are engaged in life’s activities and experience greater vitality, purpose, and meaning in life (McKnight & Kashdan, 2009; Ryan, Huta, & Deci, 2008). It could be argued that the POMS Vigor/Activity subscale measures a rudimentary form of eudaimonia by capturing differences in vitality (lively, active, energetic, cheerful, alert, full of pep, carefree, vigorous); however, it was not intended to measure eudaimonia. Established measures of eudaimonic well-being include the Psychological Wellbeing Scale, which covers six dimensions of eudaimonic wellbeing: autonomy, environmental mastery, personal growth, positive relations with others, purpose in life, and self-acceptance Scale (Ryff & Keyes, 1995), the Flourishing Scale (Diener et al., 2010), and the Warwick-Edinburgh Mental Well-being Scale (Tennant et al., 2007). The

Psychological Wellbeing Scale covers six dimensions of eudaimonic wellbeing: autonomy, environmental mastery, personal growth, positive relations with others, purpose in life, and self-acceptance (Ryff & Keyes, 1995). There are two versions - a 42-item format and a shorter 18-item version that are both suitable for investigating eudaimonic wellbeing. It includes items like *“In general, I feel I am in charge of the situation in which I live”* (environmental mastery) and *“Some people wander aimlessly through life, but I am not one of them”* (purpose in life). Other, shorter options include the 8-item Flourishing Scale (Diener et al., 2010) with items like *“I lead a purposeful and meaningful life”* or *“I am optimistic about my future”*, that capture important aspects of a successful life where participants rate their answers on a scale from 1 (strongly disagree) to 7 (strongly agree). The total score ranges from 8 to 56, with a higher score reflecting greater flourishing (for an example see Conner, Brookie, Richardson, & Polak, 2014). The 14-item Warwick-Edinburgh Mental Well-being Scale provides another useful tool to examine positive mental wellbeing (Tennant et al., 2007). This scale includes both hedonic and eudaimonic perspectives and focuses on the positive psychological outcomes only. The scale has been applied in research on fruit and vegetable consumption and showed that highest wellbeing was associated with about 7 servings per day (Blanchflower et al., 2013).

Recommendation: Positive psychological states are not simply the reverse of ill-being. For this reason, we recommend incorporating positive well-being measures into nutrition research to open up novel scientific discoveries. Large-scale nutrition surveys could benefit from including the single item happiness measure and either the OECD life satisfaction measure or the Cantril scale, which are roughly interchangeable. We also recommend the Warwick-Edinburgh Mental Well-being Scale for measuring both hedonic and eudaimonic well-being in a short questionnaire. Researchers interested specifically in

eudaimonic well-being should administer the Psychological Wellbeing Scale or the Flourishing Scale.

Innovative Real-time Mood Measurement

One of the exciting recent developments for nutritional research is to use “real-time” or “near to real time” measures of mood. Most research asks people to report their mood in general trait terms (how people feel typically), retrospectively over the past week(s) or prospectively at a given time of day usually relative to the time of ingestion of a food or supplement. Real-time measures of mood enable researchers to track mood on a daily or momentary basis over a period of time (usually 1 to 4 weeks) using technology such as internet diaries and smartphones. This latter point is important to nutrition research. Micronutrient treatment or dietary interventions should show stronger or earlier effects on mood reported in near to real-time compared to mood reported over a one-week recall timeframe or longer (see Lenderking et al., 2008, for an example in pharmacology; see also Pipingas et al., 2013). The reason is that micronutrients or dietary changes are thought to affect underlying neurotransmitter processes (Rooney, McKinley, & Woodside, 2013) which are more closely tied to actual/immediate mood responses compared to delayed reflections on mood (Conner & Barrett, 2012). Tracking mood over time can also reveal the pattern in how mood changes following the intervention – whether it is a gradual change, a sharp change, a delayed change, etc. This temporal resolution is not possible with traditional pre-post test forms of mood measurement.

Collectively, these real-time methods of assessing behaviour, physiology, affect, and cognition, repeatedly over a period of time in naturalistic or unconstrained settings, are often referred to as ‘Experience Sampling Methods’ (ESM), ‘Ecological Momentary Assessment’ (EMA; Shiffman, Stone, & Hufford, 2008), or Ambulatory Assessment (Fahrenberg & Myrtek, 1996). These are a range of real-time methods that can be used in nutrition research.

These approaches include: daily diaries, experience sampling, behavioural observations, self-monitoring systems, ambulatory monitoring of physiological functions, physical activity and/or movement, and the technological tools and hardware used to measure these features.

Table 2 presents a breakdown of these methods.

Daily Diary Methods

Daily diary methods are an example of **interval contingent sampling** and involve completing a survey (called a diary) after a specified interval of time, often once a day in the evening before going to bed. People answer questions about their experiences that occurred that day – for example, what they ate, their mood, and other experiences. Daily diaries are subject to mental averaging of the day's experience and are more subject to memory biases than prospectively administered VAS or other scales hourly in the lab or in free living situations; however, tests of end-of-day reports compared to averaged hourly reports during the same day show good correspondence (Parkinson, Briner, Reynolds, & Totterdell, 1995). The typical daily diary study lasts from one to three weeks; however the quality of data may decline after approximately 2-4 weeks of data collection possibly due to participant burden (Stone, Kessler, & Haythomthwate, 1991). If a longer time period is required, researchers can adopt a measurement burst design by surveying a few days to one week every month. Daily diaries are popular with researchers because of their ease of administration (though Internet surveys), low frequency sampling, and option to include many items. However, daily diaries are not suitable for projects requiring a more fine-grained temporal resolution across the day.

In nutrition research, daily diaries are well-suited for measuring both moods and foods together to investigate, for instance, how mood states change in response to, or in advance of, daily eating habits. For example, White, Horwath, and Conner (2013)

investigated the bidirectional relationships between daily negative and positive mood and food consumption in 281 healthy young adults using an Internet-based daily diary for 21 consecutive days. Self-reported daily servings of fruit, vegetables, and several unhealthy foods were reported each day along with the 18-item circumplex mood measure (described above) adapted for a daily format (how they felt “today”). Using multilevel linear modelling, within-person associations revealed that on days when individuals reported eating more servings of fruit and vegetables, they experienced greater positive mood. Next-day lagged analysis showed that fruit and vegetable (FV) consumption predicted improvements in positive mood the following day and not vice versa, suggesting that the FV consumption was antecedent to changes in positive mood. By utilizing a daily diary method, the authors were able to show how FV consumption was tightly yoked to changes in positive mood within the same person over time. This finding at the within-person level complements cross-sectional evidence at the between-person level that fruit and vegetable consumption is correlated positively with greater happiness and life satisfaction (Blanchflower et al., 2013).

In another study utilizing a daily diary method, Newman, O’Connor, and Conner (2007) examined the relationship between cortisol reactivity and snacking behaviours in response to stressors. Fifty pre-menopausal women completed reports of daily hassles and snack intake diaries for 14 consecutive days. Previous to this, they completed a social stress test in the lab and cortisol reactivity was measured to determine their reactivity status (high/low). Using hierarchical multivariate linear modelling, they found significant within-person associations between daily hassles and snack intake for the overall sample, where an increased number of hassles was associated with increased snack intake. Additionally, those with higher cortisol reactivity to stressors from a laboratory task were more likely to snack in response to stress than low reactors. This finding suggests that stress-reactivity may play a moderating role of eating style on stress-induced eating in daily life.

Daily diary methods may be particularly useful for intervention research. For example, a recent study by Pipingas and colleagues (2013) found no effect of multivitamin supplementation on standard measures of mood like the POMS administered at baseline, 8-, and 16-weeks following daily supplementation with a high potency multivitamin. However, participants in the active ingredient group did report lower stress, anxiety, and fatigue when they reported their mood using mobile phones at home, suggesting that the temporal proximity of real-time measures may be more sensitive to mood changes than chronic measures (Pipingas et al., 2013). However, as the authors note, these patterns could be due to mobile phone reports being made soon after participants took their daily multivitamin supplement, whereas participants refrained from taking their daily supplement at their 8- and 16-week testing settings.

Many of the shorter trait measures of mood and psychological well-being can be adapted to a daily diary format by changing the wording from “in general” to “today.” This is common practice in daily diary research. However, shorter measures (<10 items) are better suited to daily diary formats. Reliability estimates of daily diary measures cannot be computed using standard Cronbach’s alphas because the data are “nested” (multiple observations over time nested within participants), which violates assumptions of independence. Reliability should be computed taking into account the nested nature of the data – see Nezlek (2012) or Shrout and Lane (2012).

Experience sampling methods

The term “experience sampling” is used to refer to **signal contingent sampling** that involves more frequent reports combined with periodic signalling in natural settings (Csikszentmihalyi & Larson, 1987). Unlike a daily diary that is done once per day, with an experience sampling method (ESM), people are signalled semi-randomly between 6 to 10 times per day, usually over the course of several days to weeks. At each signal, participants

answer questions about their experiences at that moment. This style of sampling is suited to recording momentary experiences that are ongoing and variable (e.g., quicker changes in emotional states) and most susceptible to memory biases (e.g., pain). Although the number of items in experience sampling is usually quite small, which limits the breadth of questioning, reliability can be constructed by aggregating single items over time (Csikszentmihalyi & Larson, 1987). Researchers usually try to choose items and questions with good face validity. For example, researchers might ask people to rate how pleasant and unpleasant they currently feel (each item rated on 0 – not at all, 9 – extremely) to capture valence, or they may try to target different levels of valence and activation (energetic, relaxed, tense, sad).

In most experience sampling studies, participants are prompted by a randomly-timed signal, which is now usually accomplished using either a text-message or audible signal from a smartphone application (“app”; for a review of current options, see Conner & Lehman, 2012; and, the website for the Society for Ambulatory Assessment, <http://www.ambulatory-assessment.org/> an international society for researchers interested in mobile assessment of behaviour). Following this signal, participants respond to survey questions either by replying back to the text message, clicking through to a web survey delivered by text to their smartphone, responding directly into a survey app, or by completing a paper questionnaire (although paper questionnaires are becoming less common). Macht, Haupt, and Ellgring (2005) used ESM approach to investigate changes in eating in response to the stress of studying for exams in college students. Participants reported their emotional state, motivations to eat, and perceived functions of eating 10 times a day on 2 successive days during baseline (3-4 weeks before exams) and during the ‘stress’ period (3-4 days before exams). Control participants did not have an exam. A cellular pager was used to randomly signal participants as a prompt to perform the ratings on supplied questionnaires. Students were screened to exclude any participants who reported pathological eating patterns. In the

lead up to an exam, students experienced increased fear, tension, and emotional stress. They also reported a higher tendency to eat in order to distract from stress, but did not eat in order to relax or feel better.

In another study, Tomiyama, Mann, and Comer (2009) investigated the eating behaviour motivations of restrained eaters in their daily lives. In this study, 137 female participants used a personal digital assistant (PDA; also known as a palm top computer) to report approximately every hour (+/- 10 minutes, disregarding sleeping hours) for two days about their positive and negative mood, levels of perceived anxiety and distraction, level of hunger and whether food had been consumed since the previous response. Contrary to findings from laboratory settings, in real-life settings restrained eaters did not overeat in response to anxiety and ate more in response to hunger (Tomiyama et al., 2009).

Event Sampling

Another useful approach is **event contingent sampling**, which refers to data collection initiated by the participant following a specified event. This sampling style is well utilized in nutritional and craving research. For example, Lowe and Fisher (1983), found that when obese female college students recorded their food intake and mood using a Food and Mood Self-Monitoring (FMSM) form just prior to eating, they were more emotionally reactive and more likely to engage in emotional snacking than their 'normal weight' comparisons.

In another example, Sayegh and colleagues (1995) used a computerized telephone system to have their participants report mood and appetite. Twenty-four women with premenstrual syndrome (PMS) were enrolled in a double blind study to test the efficacy of specific beverages on PMS symptoms. Participants used the number pad of their telephone to quantify responses to mood and appetite questions before and 30, 90, and 180 minutes after consumption of the beverages. Cognitive tests were also administered by phone interview.

Results show that consuming a specially formulated carbohydrate-rich beverage known to increase serum tryptophan levels during the late luteal phase of the menstrual cycle was associated with a significant decrease in self-reported depression, anger, confusion, and carbohydrate craving 90-180 minutes after initial intake.

Event contingent sampling methods have also been used to challenge common assumptions in nutrition. For example, Stein et al. (2007) used palmtop computers to investigate the relationship between negative affect and binge eating in a sample of overweight women with binge eating disorder. They found that, contrary to prior research, negative affect did not decrease significantly following a binge. In addition, contrary to the popular restraint theory was the finding that the breaking of a “food rule” was not a primary cause for binge eating. This study underscores the important role of testing the contingencies of health behaviours and mood in real-world contexts.

Sensor Sampling – A New Frontier

One of the newest real-time methods is the use of sensor sampling to infer moods and other psychological states over time in daily life. In **continuous sensor sampling**, activities and physiological measures are recorded continuously over a designated time period using voice or audio recorders (e.g., EAR, Mehl, Pennebaker, Crow, Dabbs, & Price, 2001; cellular microphone,) pedometers, GPS, enhanced pedometers (e.g. FitBit®), and more recently from the built-in sensors in off-the-shelf smartphones. Data from continuous recording (e.g. movement or heart rate) is often useful in conjunction with self-reports of experience (Rachuri, Mascolo, Musolesi, & Rentfrow, 2011). Similarly, **adaptive sensor sampling** refers to an adjusted sampling rate of these sensors to conserve energy, reduce local memory use, and processing power (Rachuri et al., 2011).

The trend towards real-time ambulatory measures opens up other interesting tools in nutrition science. For example, heart rate monitor phone “apps”, and self-assessed salivary

cortisol levels may provide real-time anxiety data (see Schlotz, 2011). Similarly, continuous interstitial ambulatory glucose-monitoring devices (AGD; such as the Glucoday®, see Dye et al., 2010) can allow for a more comprehensive view of an individual's glucose levels in relation to diet, exercise, and mood when combined with experience sampling strategies. Meanwhile, other “apps” utilizing built-in sensors in smartphones can be used to detect stress (Lu et al, 2012), infer mood (LiKamWa, Liu, Lane, & Zhong, 2011), or to develop a pattern of a person's habits, activities, routines, and emotions (Lathia et al., 2013).

Many off-the-shelf smartphones have built-in sensors such as the accelerometer (which can be used for activity recognition), microphone (speaker, conversation detection), and GPS (location). By extracting features from the sensor-data, it is possible to draw inferences about physical activities such as running, cycling, and walking, using the accelerometer sensor and movement speed using readings from the GPS sensor (Park, Patel, Curtis, Teller, & Ledlie, 2012). Classification tasks such as speech recognition (e.g., Siri on the iPhone 4S6) can also be enhanced by accessing dictionaries available in alternative servers (Rachuri, 2012). Although these sensors were initially incorporated to improve user-experience of the smartphones, utilizing these built-in sensors can enhance the accurate observation of spontaneous behaviour and speech and they are especially useful when the social-sensing is performed passively (Rachuri et al., 2011). For example, StressSense (Lu et al., 2012) is a mobile sensing system that uses audio recorded through the microphone sensor to detect stress in the user's voice by classifying the standard deviation of pitch, perturbation, and speaking rate. Likewise, the MoodSense system can be used to infer the user's mood from information already available in smartphones by analyzing communication history and application usage patterns. For example, the MoodSense system inferred users' daily mood average with a 93% accuracy rate and sudden mood change with an accuracy rate of 74% (LiKamWa et al., 2011). Similarly, University of Cambridge's EmotionSense system

combines self-reports of mood and data recorded using the phone's built-in GPS, accelerometer and microphone, to develop a pattern of that person's habits, daily activities, social interactions, and emotions (Rachuri, 2012). EmotionSense achieves greater than 90% accuracy for speaker identification and greater than 70% accuracy for broad emotion recognition (Lathia et al., 2013).

By combining the data from built-in sensors with a log of the user's calling and texting patterns, a study of a person's smartphone can offer nutrition researchers a very useful record of their participants' natural habits, activities and routines. In addition, these software applications are becoming readily available for external researchers to utilize and modify to suit their researching needs. For nutrition researchers, this could include the incorporation of food intake recording methodologies. For example, Mymealmate is a free smartphone application developed at the University of Leeds which utilises goal-setting, progress feedback, and self-monitoring of diet, physical activity, and weight to promote user weight loss (Carter, Burley, & Cade, 2013). Another example of utilizing built-in smartphone features for nutrition research is the Remote Food Photography Method (RFPM) in which users capture images of food selection and plate waste. This method enhances individuals' food and energy intake estimation by reducing retrospective recall based error when compared to 24-hour food recall and pen-and-paper food records (Martin et al., 2009). Consistent with standard ESM protocols, customized prompts (delivered at personalized meal times) are sent to the participants to remind them to capture food images. Energy intake in a customized prompt condition was compared against doubly labelled water (DLW), considered the gold standard metabolic measure used to assess free-living energy expenditure. When customized prompts were utilized, energy intake estimated by the RFPM did not significantly differ from the energy intake measured by the more labour intensive, and expensive, DLW method. The authors reported that RFPM underestimated energy intake by

3.7%, which represented an improvement over alternative self-report methods (food records and 24-h recall which underestimate energy intake and micronutrient intake respectively, Poslusna, Ruprich, de Vries, Jakubikova, & van't Veer). If RFPM was combined with a passive sensing system such as StressSense (Lu et al., 2012), MoodSense system (LiKamWa, et al., 2011), or EmotionSense (Rachuri, 2012) it would be plausible to deploy large-scale studies with reduced logistical and financial constraints whilst achieving accurate nutrition, mood, and physical activity data.

While these applications are relatively recent, they demonstrate the potential of utilizing off-the-shelf smartphones to combine passive sensor data collection and machine learning to provide continuous monitoring of participants' emotional states, interactions, and mobility (Lathia et al., 2013). Researchers can utilize these systems to facilitate the collection of data by automatically capturing and classifying data to enhance their understanding of social interactions, nutrition, and physiological responses, on emotions, mood, and behaviour.

Recommendations:

While it is clear that good research design and careful selection of measures is of the utmost importance, nutrition researchers should aim to take advantage of real-time mood measures and advances in technology. In the near future, it will be less acceptable to rely solely upon pre- and post-test measures of mood when there are such rich data points to be measured in between assessment periods. Internet or app-based daily diaries should be used more frequently in nutrition science to track a range of daily measures of food and mood. Of course, technology cannot replace careful design of existing measures, which suggests that a multi-method approach is valuable. We also urge researchers to avoid paper-and-paper diaries or paper ESM booklets given the near ubiquitous access to the Internet and mobile phones. For a review of technology and ESM-capable software, see www.ambulatory-assessment.org.

Conclusion

Multiple options are available for measuring mood in nutrition research. Some of these involve more traditional approaches of examining trait and state moods using a paper-and-pen questionnaire. However, more recent technological advances and multimodal research approaches now allow us to capture new facets of the relationship between nutritional factors and moods. While trait reports of global or longer-term retrospective well-being are still the method of choice for cross-sectional studies to establish links between typical eating patterns and macro-level moods, real-time approaches can be extremely useful for intervention research where real-time measures of mood can potentially show earlier changes in mood than traditional measures. These approaches could also help nutrition researchers illustrate micro-level changes in mood as a function of nutrition intake, offering a finer grained resolution of temporal sequencing that cannot be achieved with pre-and post-test reports. However, the method utilized for measuring mood in nutrition research in any specific project needs to be suitable for the aims of the research and the study population. Most importantly, the growing development in the fascinating new area of the nutrition-mood link research requires understanding of the range of mood measures available to researchers.

Summary of Main Points

- Consider the main aims of your research before deciding on the mood measures. Trait measures are suitable for measuring associations; state measures are better suited for capturing change.
- When using depression measures, be aware of the potential overlap between symptoms of nutritional deficiency and symptoms of depression (e.g., tiredness, difficulties concentrating).
- Do not ignore positive mood states and other measures of positive psychological functioning. At minimum, include mood measures that assess both negative and positive mood states. If possible, include other measures of psychological well-being or flourishing, in addition to traditional measures of ill-being (depression, anxiety, etc.).
- Ditch the pen-and-paper diaries in favour of electronic technology as it is easier to track completion, compliance, and involves less participant burden.

Current Trends

- A trend towards including measures that assess both negative and positive mood states is warranted.
- New trends in ambulatory research may give rise to the use of subjective state measures as well as real-time, objective physiological measures.
- Real-time data capture approaches are beginning to integrate more technologically advanced platforms for research such as SMS based, smart phone app-based, and internet-based experience sampling with an emphasis on incorporating a range of ambulatory methods. These methods often necessitate advanced forms of statistics such as multilevel modelling.

Recommendations for Measuring Mood

- Comprehensive mood measures that include both negative mood states (e.g., sadness, irritable, tense) and positive mood states (e.g., excited, content, inspired).
- Aspects of mood can be assessed separately, or embedded within more general mood assessment tools.
- Researchers should endeavour to utilize multi-modal research strategies by incorporating ESM in conjunction with traditional measures.
- Researchers should endeavour to incorporate smart phone capabilities where appropriate and should monitor the rapid progression of this field as it continues to transform.
- Researchers should trial their ESM-based study themselves to ensure there is no significant participant burden, a small thing that may irk you for one day, is likely to infuriate a participant over a longer period of time.

Box 1 – How Nutritional Factors affect Mood

- Observational research shows a correlation between consumption of healthy foods and less depressed mood.
- There is evidence that specific micronutrients (e.g., iron, vitamin D, folate, selenium, magnesium) are also associated with less depressed mood.
- Fruit and vegetable consumption is related to positive mood and life satisfaction.
- There is evidence that supplementation with micronutrients can reduce depressive symptoms. The evidence base is strongest for supplements containing multiple micronutrients. There is also initial evidence that micronutrient supplementation (e.g., iron) can increase feelings of vigor.

Table 1 Measures and sampling techniques suitable for studies on the relationship between nutrition and mood.

Measure	Author	Description
Center for Epidemiological Studies – Depression Scale (CES-D)	Radloff (1977)	A measure of depressed mood, suitable for use in a community sample.
Beck Depression Inventory (BDI and BDI-II)	Beck et al. (1961); Beck et al. (1996)	A measure of depression severity, designed for use in clinical population. Researchers must consider the crossover between somatic depression symptoms, and the physical symptoms of nutritional deficiency.
The Geriatric Depression Scale (GDS)	Yesavage et al. (1983)	A measure of depression, specifically for use in elderly population
Edinburgh Postnatal Depression Scale (EPDS)	Cox et al. (1987)	A measure of depression, specifically for use of postpartum women (within eight weeks of giving birth)
The Hospital Anxiety and Depression Scale (HADS)	Zigmond & Snaith (1983)	A screening tool for indications of anxiety and depression. This tool is considered efficient to measure depression and anxiety symptoms simultaneously - a recommended tool for nutritional

		research.
State Trait Anxiety Inventory (STAI)	Spielberger (1983)	A self-report measure of both current and general feelings of anxiety. This measure is commonly used in supplement studies.
Hamilton Anxiety Rating Scale (HAM-A)	Hamilton (1959)	A clinician rated measure of anxiety severity. Researchers must consider the potential crossover between somatic anxiety symptoms and physical symptoms of nutritional deficiency. This measure has also shown to have crossover with depressive symptomatology.
Beck Anxiety Inventory (BAI)	Beck & Steer (1993)	Includes both cognitive and somatic components of anxiety and is suitable for clinical populations
General Health Questionnaire (GHQ-12)	Goldberg & Williams (1991)	A brief self-report screening tool for common mental health disorders, with subscales including: depression, anxiety, somatic symptoms, and social withdrawal. This measure provides an indication of general psychological distress, rather than measurement of particular mood states.
Structured Clinical Interview for DSM-IV-TR, non-patient edition (SCID-	First et al. (2002)	A semi-structured diagnostic interview, which indicates the presence and severity of a DSM-IV diagnoses. Whilst being the ‘gold standard’ instrument to indicate the presence of a mental illness, it requires extensive training to administer.

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Profile of Mood States (POMS and POMS2)	McNair et al. (1971) Heuchert & McNair, (2004)	A total mood measure, which incorporates a range of different negative moods and a measure of positive mood. The inclusion of ‘vigor’ is important given the relationship between healthy eating and feelings of energy. There are several shortened versions.
Positive and Negative Activation Schedule (PANAS)	Watson et al. (1988)	A mood measure which yields separate measures of positive and negative activation states. This measure is limited to high activation states, rather than lower-level activation (e.g. fatigue). There is also a shortened version available.
Bond-Lader Visual Analogue Scale (VAS)	Bond & Lader (1974)	A measure of various moods using a continuum, in which individuals indicate their position along a continuous line between two points (e.g. happy-sad). VAS scales may provide a good option for the measurement of mood in children.
Affective Circumplex	Barrett & Russell (1999)	A self-report measure encompassing both positive and negative affect. This measure also reflects high, medium, and low levels of activation, as well as differentiates between state and trait affect.

Fordyce Happiness Measure	Fordyce (1998)	A remarkably quick single item instrument to measure happiness with good reliability and stability.
Subjective Happiness Scale (SHS)	Lyubomirsky & Lepper (1999)	A quick 4-item measure of happiness in general, and in comparison to peers.
OECD life satisfaction measure	OECD (2013)	Measure of life satisfaction used in OECD country surveys, suitable for nutrition research.
Cantril Scale	Cantril (1965)	Quick single item measure of life satisfaction, where respondents rate their life from worst possible to best possible.
Satisfaction with Life Scale	Pavot & Diener (1993)	This 5-item questionnaire measures global cognitive judgments on satisfaction with life.
Psychological Wellbeing Scale	Ryff & Keyes (1995)	A self-report measure of various dimensions of eudaimonic wellbeing.
Flourishing Scale	Diener et al. (2010)	A measure of flourishing, capturing aspects of what is considered a ‘successful’ life.

Warwick-Edinburgh Mental Well-being Scale	Tennant et al. (2007)	A measure of hedonic and eudaimonic wellbeing, with a specific focus on positive psychological outcomes.
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Table 2. Sampling strategies suitable for studies on the relationship between nutrition and mood.

Sampling strategy	Example	Description
Daily diary method	Conner & Lehman (2012); e.g. White et al. (2013)	A method that requires individuals to complete a survey each day, typically at the end of each day. This diary can be tailored to include measures of mood, daily nutritional intake, and other aspects of experience that vary on a daily basis. Daily diaries are useful for testing covariation between food and mood and for detecting mood changes in intervention/supplementation trials. Diary surveys can also be delivered through smartphones, which can enable large-scale delivery.
Experience sampling method / Ecological momentary assessment	Conner & Lehman (2012); e.g. Macht et al. (2005); Lathia et al. (2013)	A method that utilizes pagers, text messaging, or mobile phone “apps” to signal self-report measurements multiple times per day, typically on a semi-random schedule. ESM is used to measure current mood or other experiences (e.g., stress, pain) that are variable and ongoing across a short period of time in naturalistic free-range (ambulatory) settings. Smartphone usage

will increase feasibility of this method in the near future.

Event contingent experience sampling	e.g. Lowe & Fisher (1983)	A method in which mood and other experiences are measured followed a specified event. This method is commonly used to tap mood that follows infrequent events (e.g., following binges).
Continuous sampling/ Adaptive sensor sampling	e.g. Rachuri (2012)	A method in which psychological and physiological experiences are measured using various technologies including, GPS, voice recorder, microphone, text messaging and call logs. While not yet utilized in the field of nutrition, this continuous sampling method offers insight into routines and habits as individuals navigate their daily life.

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