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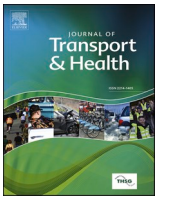

Review and assessment of self-reports of travel-related emotional wellbeing

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ABSTRACT

Introduction: Travel behavior research has only started to address how travel affects emotional wellbeing. The development of measurement methods is an important goal of this research.
Methods: A review and assessment of methods of measuring travel-related emotional wellbeing is presented guided by a conceptual framework specifying what is measured (cognitive evaluations, emotional responses, or moods), the way it is measured (proactively, instantaneously, or retrospectively), and when it is measured (before, during, or after travel). Anticipated, current, residual and recalled moods are the objects of the measurement. Only studies of commuting or other types of daily travel are addressed.
Results: We find that no research has measured anticipated moods, some research has measured current moods before, after and during travel, and most research has measured recalled moods.
Conclusions: The most valid and reliable method is to measure current mood instantaneously at several points in time, before, during, and after travel. A measure of emotional wellbeing can then be obtained by objective aggregation. An approximate more feasible method is to retrospectively measure recalled moods for a given specified time period that may not only include travel. The available methods for measuring recalled moods have acceptable psychometric properties but research is needed to validate these methods by comparing the results to an objective aggregation of instantaneous measures of current mood at different points in time.

1. Introduction

Travel behavior research attempts to understand how people cognitively evaluate travel depending on cost, travel time, accessibility, and reliability (Redman et al., 2013). This understanding is important for the implementation of changes in the quality of travel such that travelers' satisfaction increases. Research has however only started to address how travel affects people's feelings.[1] This

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[1] Feeling is the experiential aspect of emotional responses and moods (Russell, 2003, 2014).

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focus of research is arguably important due to the potential relationships between travel-related feelings and impacts of travel on wellbeing.[2] The development of measurement methods is at this stage an important goal of the research. Our aim in this paper is to review and assess methods of measuring travel-related emotional wellbeing.

Our primary focus is *emotional wellbeing* (EWB). In recent research (see Section 4), EWB has frequently been measured as the balance of a person's reported positive and negative feelings during a given time period. We argue that this measure is not satisfactory. Instead, we propose that EWB should be defined as how people feel at the moment, usually referred to as *current mood*.[3] Further elaboration follows in Section 3. One would however want to know how people feel not only at a single moment but during a more extended time. This would require that current mood is measured recurrently and then aggregated. Another possibility is that people are asked to themselves retrospectively report their current moods during a specified time period.

The different concepts we introduce in this paper are interrelated as shown in Fig. 1. Cognitive evaluations influence satisfaction with travel but may also evoke emotional responses that in turn influences current mood and EWB when aggregated over time. EWB has potential broader wellbeing consequences and is another factor that may influence satisfaction with travel.

Table 1 illustrates that our review and assessment of methods for measuring travel-related EWB focuses on what is measured (cognitive evaluations, emotional responses, or mood), the way it is measured (proactively, instantaneously, or retrospectively), and when it is measured (before, during, or after travel). Anticipated, current, residual and recalled moods are the objects of measurement. Only studies of commuting or other types of daily travel are considered.

In the next section we present an alternative behavioral perspective. A conceptual framework is then developed that distinguishes between cognitive evaluations, emotional responses, and current moods. A brief review of research that demonstrates relationships between EWB, life satisfaction, mental and somatic health follows.[4] In the subsequent section, we describe and assess the different measurement methods applied in previous studies of work commutes or other daily travel, either before travel, during travel, or after travel. The final section summarizes, discusses implications, and suggests future research directions.

2. A behavioral perspective on measurement of travel-related emotional wellbeing

In the context of cost-benefit analyses, assessing satisfaction with travel is commonly based on utility-maximization theory (Carse, 2011; De Vos et al., 2016). It is thus assumed that choices people make maximize (random) utility such that it results in satisfaction with the outcomes of the choice. This assumed correspondence between utility and satisfaction is challenged by Kahneman et al.'s (1997) distinction between experienced utility and decision utility. Experienced utility is the satisfaction with the outcome of a choice (i.e., the degree to which it is good or bad), whereas decision utility is the degree to which the outcome is desired when the choice is made. Empirical research (e.g. Kahneman and Sugden, 2005; Loewenstein and Uebel, 2008) has shown that experienced utility differs from decision utility. Still another concept is anticipated utility referring to an expectation of the experienced utility. Although anticipated utility and decision utility both precede experienced utility and seem to have the same assumed role to influence choice,[5] they nevertheless differ in that anticipated utility is a cognitive expectation of experienced utility associated with the outcome of a choice and should therefore be more closely related to experienced utility (Mellers, 2000; Loewenstein et al., 2001). In contrast, decision utility does not have any surplus meaning over and above its operationalization as weights placed on objective attributes assumed to influence choice (e.g. Ben-Akiva and Lehman, 1985).

If utility inferred from travel choices does not have an invariant relationship to satisfaction with travel, other measurement approaches are needed. A straight-forward approach employed in service research (Oliver, 2010) is to elicit self-reports from travelers of how satisfied they are. Travel is extended in time like many other services. A choice of travel may therefore result in a sequence of outcomes. For instance, a public transport trip may consist of several modes, for instance walking to the bus stop, the bus ride itself, and walking to the final destination. These stages of the trip may also differ in other respects (e.g. urban density, congestion, in-vehicle crowdedness). Kahneman (2000a, 2000b) proposes that each momentarily outcome in a sequence has an instant (experienced) utility. In evaluating larger units of travel, an aggregation of instant utilities needs to be made. An objective aggregation would be possible if recurrent measurements are made of instant utilities. Another possibility is that travelers are asked to themselves retrospectively evaluate the sequence of outcomes. This is referred to as remembered utility since in contrast to evaluations of momentarily outcomes (instant utilities), retrospective evaluations of sequences of outcomes depend on memory of the sequences.

The behavioral perspective is adopted in the following analysis of travelers' current mood and emotional wellbeing.

3. Conceptual framework

This section takes the distinction between experienced utility and decision utility a step further by presenting a conceptual framework that distinguishes between cognitive evaluations (instant utilities), emotional responses, and moods. Gärling (2018, 2019)

[2] Referring broadly to life satisfaction, mental health, and somatic health.

[3] The basis for the proposed relationship between current mood and emotional wellbeing is that current mood has a regulative function to provide information about the wellbeing status of the organism in relation to pressures of the environment (Diener et al., 2015; Lazarus, 1991).

[4] For more comprehensive reviews of wellbeing related to travel, see Chatterjee et al. (2019), De Vos et al. (2013), Ettema et al. (2010, 2016), Mokhtarian (2019), and Mokhtarian and Pendyala (2018).

[5] Originally, utility was conceptualized as being inferred from choice (revealed preference) assuming that utility is maximized. It is a more recent idea that choice is determined by and therefore predicted from utility.

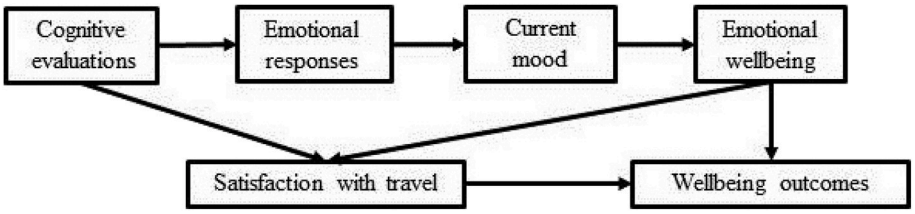

Fig. 1. The relationships between constructs.

Table 1
Measurements of travel-related mood.

Properties	Before travel	During travel	After travel	
	Anticipated mood	Current mood	Residual mood	Recalled mood
Proactive vs instantaneous vs retrospective	Proactive	Instantaneous	Instantaneous	Retrospective
Cognitive evaluation vs emotional response vs mood	Cognitive evaluation	Emotional response contingent on cognitive evaluation and mood contingent on emotional responses	Updated mood contingent on emotional responses during travel	Cognitive evaluation contingent on moods during travel

shows how these concepts may be applied to analyses of effects of travel on feelings.

We first assume that any choice outcome with objective characteristics is subject to cognitive evaluations on two orthogonal evaluation dimensions (see Fig. 2), one ranging from displeasure to pleasure through neutral and another ranging from deactivation to activation (or arousal) through neutral (Russell, 1980, 2003; Posner et al., 2009; Yik et al., 2011). The two dimensions of pleasure-displeasure and activation-deactivation may be aggregated to a good versus bad evaluation approximately coinciding with the pleasure-displeasure dimension (Kahneman, 1999; Västfjäll and Gärling, 2002).

We propose in equation (1) that a modified Prospect Theory value function (Kahneman and Tversky, 1979) describes evaluations of choice outcomes as good versus bad (*IU*). The objective choice outcomes are denoted X assuming they are ordered along some quantitative continuum of intensity, frequency, or duration. The evaluations are made relative to a changing adaptation level (*AL*). Evaluations are good above the adaptation level ($X > AL$), neutral at the adaptation level ($X = AL$), and bad below the adaptation level ($X < AL$). Some extremely negative choice outcomes may always be evaluated as unacceptable (Hsee and Zhang, 2010). We define *UL* as a fixed unacceptable level. A possible specification is hence,

$$IU(X) = \begin{cases} -\infty & 0 < X \leq UL \\ -a_B|X - AL|^b & UL < X < AL; a_B, b > 0 \\ a_G(X - AL)^b & AL \leq X; a_G, b > 0 \end{cases} \quad (1)$$

In contrast to the fixed unacceptable level, the adaptation level may change and thus influence the evaluation of outcomes. Such changes have been labelled hedonic adaptation (Frederick and Loewenstein, 1999). After some time significantly better or worse

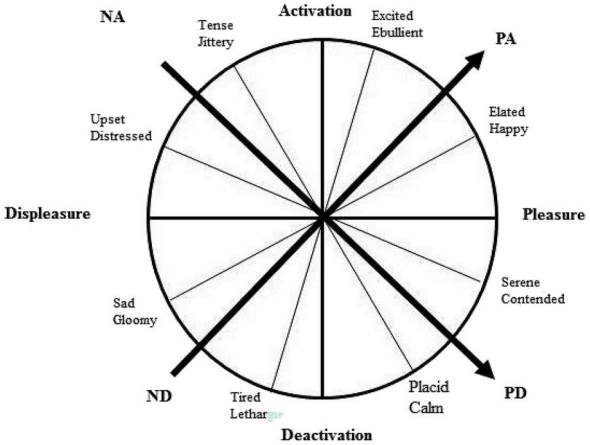

Fig. 2. The circumplex model of affect (adapted after Yik et al., 2011).

outcomes may be evaluated as normal.

Several emotion theories (e.g., Carver and Scheier, 1990; Lazarus, 1991; Oatley, 2009) propose that an emotional response is evoked if and only if a cognitive evaluation has personal relevance, for instance, if it facilitates attainment of a positive personal consequence or avoidance of a negative personal consequence. Even if the cognitive evaluation deviates from neutral in being good or bad, it may thus still not evoke an emotional response unless being personally relevant. In contrast, evaluations of unacceptable outcomes are by definition personally relevant and therefore invariably evoke emotional responses. Furthermore, mood is to some degree influenced by emotional responses. Mood is according to Russell (2003, 2014) a prolonged feeling state. Emotional responses are distinguished from mood in being consciously attended and causally attributed to an object, have a beginning and an end, and are stronger than mood that resides in the background (Lazarus, 1991). An emotional response triggers several transient feeling, physiological, and behavioral changes. We propose that this may result in an altered current mood that lingers after the emotional response has dissipated. It does this if the emotional response is judged to have longer-term, not easily reversible consequences. When measured on the same scale, the mood change is a fraction of the emotional response such that, at some lower rate, it changes with the degree to which the evaluation of the choice outcome is positive or negative. The following model has these properties (Gärling, 2018, 2019):

$$\mathrm{CM_i} = \begin{cases} \mathrm{CM_{i-1}} + (\mathrm{CM_{max}} - \mathrm{CM_{i-1}})(1 - \exp(-\mathrm{ER_i})) & \mathrm{ER_i} = \mathrm{c_i IU_i} \geq 0 \\ \mathrm{CM_{i-1}} - (\mathrm{CM_{i-1}} - \mathrm{CM_{min}})(1 - \exp(\mathrm{ER_i})) & \mathrm{ER_i} = \mathrm{c_i IU_i} \geq 0 \end{cases} \quad \mathrm{i} = 1, \; 2\ldots, \mathrm{n}; 0 \leq \mathrm{c_i} \leq 1; \mathrm{CM_{min}} < 0 \leq \mathrm{CM_{max}} \tag{2}$$

where CM_i is current mood changed from CM_{i-1} when an emotional response ER_i is evoked by the evaluation IU_i of the choice outcome i in the sequence from 1 to n. Both CM_i and ER_i are assumed to vary on a single continuum from negative to positive through neutral. Changes in CM_i are asymptotically bounded upward and downward by CM_{max} respectively CM_{min}. ER_i is a fraction of IU_i with the coefficient c_i proportional to the impact of the emotional response.

It has been argued that emotional responses are not possible to remember but only to reconstruct from memory of the circumstances that evoked the emotional responses (Robinson and Clore, 2002). Retrospective evaluations of past events are therefore based on cognitive evaluations subject to memory distortions, either forgetting of the objective characteristics or inaccurate inferences of an emotional response to these objective characteristics. For instance, retrospective reports tend to lead to inferences that emotional responses are stronger than they actually were (Wilson and Gilbert, 2008). Another memory distortion is due to influences from mood at recall (Blaney, 1986). Being in a positive mood increases the likelihood of recall of previous positive outcomes and being in a negative mood the reverse. The weight parameter v in the following equation captures the influence of current mood at recall,

$$\mathrm{E_{n+1}} = \mathrm{vCM_{n+1}} + (1 - \mathrm{v})\left(\frac{1}{\mathrm{n}}\sum_{\mathrm{i=1}}^{\mathrm{n}}\left(\mathrm{w}\left(\frac{\mathrm{i}-1}{\mathrm{n}-1}\right)^{\mathrm{s}} + (1-\mathrm{w})\left(\frac{\mathrm{n}-\mathrm{i}}{\mathrm{n}-1}\right)^{\mathrm{s}}\right)\mathrm{dIU_i}\right) 0 \leq \mathrm{d}, \mathrm{v}, \leq 1; \mathrm{s} > 1 \tag{3}$$

The poorer the memory of the sequence of choice outcomes, the more likely it is that mood at the time of recall (CM_{n+1}) influences the evaluation (E_{n+1}). Equation (3) also models several other memory distortions. d is a general memory decay parameter that decreases with time until the evaluation is made, whereas $s > 1$ represents that the beginning and end are remembered better than the middle and, *ceteris parabus*, have more impact on the evaluation. The parameter w captures differences in primacy and recency effects in free recall (Davelaar et al., 2005), that is, that the end and beginning may not be remembered equally well and thus have different impacts on the evaluation.

In equation (3), instant utilities are aggregated by averaging. Averaging is a general aggregation rule (e.g. Cojuharenco and Ryvkin, 2008; Seta et al., 2008a, 2008b). Several studies have observed deviations from this rule in demonstrating the peak-end rule (e.g. Redelmeier et al., 2003; Schreiber and Kahneman, 2000). According to this rule, the final outcome (end) and the most intense outcome (peak) are averaged such that they receive disproportionately large impacts on the evaluation of the outcome sequence. This is a special case of Equation (3).

3.1. Emotional well-being, life satisfaction, and health consequences

In this section we briefly review research that demonstrates direct and indirect relationships between EWB, life satisfaction and mental and somatic health. Diener and Suh (1997) originally proposed the following three components (taken together commonly referred to as subjective wellbeing [6], see for reviews Busseri and Sadava, 2011; Tov, 2018): (1) A cognitive evaluation of life satisfaction (LS), (2) experiences of positive feelings (PA), and (3) experiences of negative feelings (NA). LS is frequently assessed by means of the 5-item *Satisfaction with life scale* (Diener et al., 1985a), where self-report statements like "in most ways my life is close to my ideal" or "I am satisfied with my life" are rated on 7-point Likert scales ranging from "totally disagree" to "totally agree".[7] Research has demonstrated that LS depends on life circumstances both within countries (Lyubomirsky et al., 2005) and between countries (Helliwell et al., 2017). People with a higher income have higher LS, and LS increases with higher national levels of income over time (e.g., Sacks et al., 2012). LS usually has a U-shaped relationship to age (Mroczek and Spiro, 2005). Marriage tends to increase, divorce or death of

[6] In assessments of subjective wellbeing (Diener and Suh, 1997; Heliwell et al., 2017) these components are considered separately and in general considered to be equally important.

[7] It is also common to use single-question measures, such as the Ladder of Life Scale used in the Gallup World Poll (www.gallup.com/services/170945/world-poll.aspx) or the two separate single questions asked in the World Values Survey (www.worldvaluessurvey.org).

spouse to decrease LS (Winter et al., 1999). Unemployment has been shown to reduce LS, in particular when there is little social support (Lucas et al., 2004). The results for sex are mixed, some studies showing that women have higher LS than men, others that there are no differences, and still others that sex differences vary across the life course (Tesch-Römer et al., 2008). People are more satisfied with their life in countries with high income, freedom, social support, and health, and less satisfied in countries with high corruption (Helliwell et al., 2017).

The feeling components (PA and NA) have moderate positive correlations with LS and are therefore both conceptually and empirically distinct (Busseri and Sadava, 2011; Tov, 2018). Conventional self-report rating scales are frequently used to measure PA and NA including the *Positive Affect and Negative Affect Scale* (PANAS, Watson et al., 1988) or the *Swedish Core Affect Scale* (SCAS, Västfjäll et al., 2002; Västfjäll and Gärling, 2007). An instantaneous self-report of PA or NA (an answer to the question "How do you feel right now?") would reflect a person's current mood influenced or not by an emotional response to some concurrent event (Killingworth and Gilbert, 2010; Stone et al., 1999). In retrospective measurements people report the frequency (or duration and intensity) of PA and NA (deviations from a neutral mood) recalled during a specified time interval. EWB is defined as an aggregated index of the balance of PA and NA. One index is the ratio of the frequencies (Diener et al., 1985b), another index the average intensity of PA minus the average intensity of NA (Kahneman et al., 2004), and a third index the difference between duration-weighted intensities (Krueger and Schkade, 2008).

At an individual level, EWB is to some extent related to stable personality traits (Tkash and Lyubomirsky, 2006). Among the Big Five personality traits, extraversion, emotional stability, and conscientiousness have the strongest relationships with EWB (Steel et al., 2008). The relationship between personality traits and EWB is generally proposed to be both indirect and direct (Steel et al.). For instance, low emotional stability is often considered to be a tendency to experience negative emotions, such as anger, anxiety, or depression. On the other hand, conscientiousness and extraversion may have an indirect relationship to EWB. For instance, extraversion facilitates social relationships and conscientiousness successful attainments of important goals which both affect EWB (Soto, 2015).

Another line of research shows that EWB increases by intentional activities in which people engage and which require some effort (Sheldon and Lyubomirsky, 2006). For instance, exercising regularly, devoting effort to meaningful causes, eschewing social comparisons and contingent self-evaluations, and practicing certain virtues, such as gratitude, forgiveness, and thoughtful self-reflection are intentional activities that have been found to increase EWB.

Most studies find that LS, PA, and NA correlate with a wide variety of health consequences (see review by Diener and Chan, 2011), but it is unclear whether one specific component is more important than the others. In line with this conclusion, a meta-analysis (Martin-Maria et al., 2017) found a decreased risk of morbidity and mortality but no differences between LS, PA, and NA. Still, Kushlev et al. (2019) showed that PA has a stronger association with positive health behaviors than LS and NA. Interventions increasing EWB may thus indirectly improve health. EWB has however not been found to increase recovery from illness (Diener and Chan, 2011). It has also been shown that specific health conditions such as heart disease and strokes reduce LS and EWB (Strine et al., 2008; Shields and Price, 2005).

In summary, there are ample evidence of health consequences of EWB and LS. Evidence also shows what factors (including travel, see Section 5) influence EWB and LS. However, the possible indirect relationships between these factors and health consequences need to be studied in future research. One issue that also needs to be addressed is whether the association with health is bidirectional as suggested by Steptoe (2019).

4. Measurement of travel-related emotional wellbeing

4.1. Before travel

In travel behavior research investigating evaluations before travel, the questions most frequently asked is what expectations travelers have about satisfaction with a new mode and whether the expectations are consistent with satisfaction after having switched to the new mode. In psychological research expectations have been shown to underestimate positive and negative feelings as well as their duration. Wilson and Gilbert (2008) proposed that memory of previous evaluations influence future evaluations. Better or worse evaluations of past events are more likely to be remembered and their intensity remembered to be higher than experienced. According to the focusing illusion (Schkade and Kahneman, 1998), expectations may be biased in a positive or negative direction because only a limited number of salient aspects are attended such that their impact on the evaluation dominates. An example is that car drivers switching to public transport focus on annoying factors such as having to wait at the bus stop and compete for a seat, while overlooking the possibility to read a newspaper on board. Experiencing the actual outcome when traveling by public transport, it will turn out that many other aspects influence satisfaction than expected, thus possibly dampening a negative evaluation.

Several studies have demonstrated a positive relationship between evaluations before and after travel (e.g. Bamberg and Schmidt, 2003; Cao and Ettema, 2014; Ye and Titheridge, 2017). In addition, De Vos et al. (2016) found that travelers holding a positive pre-travel evaluation of the most recent leisure trip by car reported both more positive feelings during car travel and, in retrospect, cognitively evaluated these trips more positively. The same results were observed for the most recent leisure trip by bicycle. The result was however less clear for the most recent leisure trip by public transport, where a positive pre-travel evaluation was only related to cognitive evaluations.

In a field experiment Abou-Zeid et al. (2012) investigated Swiss car commuters volunteering to make 2–3 days switch to public transport. Overall, lower satisfaction was initially reported with public transport than car, which was consistent with a revealed car preference. The results further showed, first, that those who initially reported a higher satisfaction with public transport were more

likely to continue to use this mode after the switch, and, second, that satisfaction with the car commute increased directly after switching. The latter may be due to an increased attention to positive aspects of the car commutes, probably by making comparisons with the commutes by public transport. After 4–5 months, however, satisfaction with the car commute had returned to the initial level. The experiment was repeated in the US (Abou-Zeid and Ben-Akiva, 2012) with a more varied outcome. One group returned to using their cars despite initially reporting a lower satisfaction with public transport. Another group reporting higher satisfaction with public transport than car continued commuting by public transport.

Pedersen et al. (2011a, 2011b) conducted a similar field experiment in which car users were contracted to switch to public transport for one month. Measures were made of expected satisfaction before, satisfaction during, and satisfaction two years after the one-month public transport use. The participants reported a higher satisfaction with public transport during its use than they expected before. Two years after, memory of the satisfaction with public transport had returned to, and was even slightly lower than expected before. This suggests that travelers' evaluation of an alternative mode may remain biased even after a positive outcome.

Evaluations before travel are to some degree related to mode choice (De Vos et al., 2016). It is however not firmly established that evaluations before travel are related to mood during travel. Besides, the question "How do you anticipate you will feel during your trip?" have not been directly asked. Nevertheless, this is a question people are likely to ask themselves that has consequences for the choice they make. A trip with a crowded bus, for instance, may be anticipated to be distressing. A long trip may be anticipated to be tiring. Current mood may also be measured before travel (e.g. while waiting) which would likely have influences on the subsequent travel experience.

4.2. During travel

A trip is parsed by travelers into discrete, consciously attended events (above referred to as choice outcomes). Events that deviate from normal result in evaluations of good versus bad. Such good-bad evaluations are labelled critical incidents (Flanagan, 1954; Gremler, 2004). Empirical service research has examined the frequency of positive and negative critical incidents (e.g., Petrick et al., 2006), but less is known about their intensity and duration. Examples of positive and negative critical incidents in public transport include a speed change, cellphone ring signals, seat availability, and positive driver contacts. Noise, crowding, interesting window view, and conversation with friend are examples of negative and positive continuous stimuli impinging on travelers. Such stimuli may still be attended to and evaluated intermittently (Ariely and Zauberman, 2000, 2003). For instance, a negative evaluation of noise may depend on that it interferes with desirable activities such as reading or talking with others (Wallenius, 2004). An alternative may be that continuous stimuli are only attended if exceeding a combined intensity and duration level.

Critical incidents having personal relevance for travelers may or may not evoke emotional responses (Friman, 2004). An example is that a delay is likely to always be evaluated as bad but only evokes an emotional response if having personal relevance such as being late for an important appointment. If evaluated as unacceptable, critical incidents would always evoke emotional responses. Examples are vehicle breakdowns or accidents leading to failures to reach the destination. Measurements of emotional responses and mood during travel by means of observations, surveys (e.g. on-board interviews, experience sampling), and physiological measures (e.g. excretion of stress hormones, heart rate) have been applied in past research (Echeverri, 2005; Novaco and Gonzales, 2008). New technique-driven approaches using smartphones to track travelers by GPS and promptquestionnaires while traveling are now being developed. In one study Dunlop et al. (2014) repeatedly sent questionnaires to participants' smartphones during public transport journeys. They observed heightened anxiety and discomfort when the participants encountered undesirable events. Ettema and Smajic (2015) used a smartphone app to measure pedestrians' mood during their walking trips, and also to record their perceptions of the environment, supported by pictures taken.

Friman et al. (2017b) assessed current mood ("How do you feel right now?") by means of questionnaires sent to participants' smartphones. They did that before and after a morning commute to work. If mood is updated due to emotional responses evoked by cognitive evaluations of critical incidents, mood may at the end of the commute be viewed as an instantaneous measure of EWB resulting from the commute and spilling over to later activities (Gärling, 2018, 2019). The results showed that only positive emotional responses during the trip influenced the change in mood from before to after the commute. A caveat is that the emotional responses to critical incidents were reported retrospectively. Glasgow et al. (2019) similarly measured mood by means of a smartphone questionnaire answered after each trip during a full week. GPS was used to make possible to associate mood changes with travel mode, activities carried out, and environmental features. Another study collected survey data on how happy people were with their current activity (including travel) obtained by means of smartphones which also registered external information (Raveau et al., 2016). Comparisons made between on-line and retrospectively reported happiness showed deviations of the results of the latter from the results of the former in line with what was expected if memory errors play a role.

A caveat is that both the old and new techniques work best for public transport and walking. They are difficult to apply for travel modes that require travelers' directed attention. Recent advances in portable physiological measurement techniques are therefore promising complements for other modes. With easy-to-wear head-mounted EEG and eye-movement measurement methods, it is becoming possible to assess brain states during travel by any mode. According to Miller (2012), smartphones are revolutionizing behavioral research, and many companies are developing bluetooth biosensors assessing a number of physiological parameters. Future research would benefit from adding such techniques to assessments of how travelers respond emotionally to critical incidents, and to compare the results to on-line self-reports.

4.3. After travel

In order to measure travel-related EWB, aggregation over time is necessary to assess if and how current mood changes. A possibility is to let participants themselves do the aggregation (Kahneman, 2000a, 2000b). Measurement immediately after a trip is then the most feasible procedure. EWB also needs to be assessed for longer time intervals with the aim of determining the role of travel.

By using the *Day Reconstruction Method* to obtain retrospective reports of emotional responses to daily episodes, Kahneman et al. (2004) found commuting to be associated with a negative mood. In Morris and Guerra (2014), data from a large sample were analyzed. Excluding purely recreational travel, a retrospective aggregated measure of mood experienced during the preceding day showed that daily travel only accounts for a few percent of the daily mood variance. This was still not a trivial effect when compared to other activities included in the same study. Another study (Jakobsson Bergstad et al., 2011, 2012) found direct effects of travel on a retrospective measure of the weekly mood as well as indirect effects through affect associated with performance of frequent travel-dependent out-of-home activities during the week. In Olsson et al. (2013), a retrospectively measured positive mood decreased with the duration of work commutes. Analyzing data from a large-scale study, Feng and Boyle (2014) concluded that long work commutes are associated with negative mood more strongly for women than men. In a longitudinal study, Martin et al. (2014) found that public transport may be more beneficial to emotional well-being than driving. However, Humphries et al. (2013) failed to find any relationship between commuting by physically active modes and emotional well-being. None of the reviewed studies measuring mood changes was able to directly relate the changes to critical incidents evoking emotional responses during travel.

The multi-item *Satisfaction with Travel Scale* (STS) (Ettema et al., 2011; Friman et al., 2013) was developed to measure after-travel evaluations of any form of travel. It has been extensively used in recent years (e.g. Andersson and Nässén, 2016; De Vos, 2018, 2019; De Vos et al., 2015; Ettema et al., 2013; Friman et al., 2017a, 2017b; Olsson et al., 2012; Singleton, 2019; Smith, 2017; Suzuki et al., 2014; Westman et al., 2017; Ye and Titheridge, 2017). STS combines a cognitiveevaluation dimension with two orthogonal dimensions to retrospectively assess mood or EWB during travel. The items in STS are given in Table 2. The mood dimensions are measured with validated adjective scales in SCAS (Västfjäll et al., 2002; Västfjäll and Gärling, 2007) derived from the affect circumplex (Yik et al., 2011) (see Fig. 2). In order to attain a high content validity, the scales tap alertness, boredom, relaxation, and stress that are frequently experienced during travel. Therefore, adjective scales are included that vary from positive activation to negative deactivation (PAND obtained by averaging items 4 to 6) and from positive deactivation to negative activation (PDNA obtained by averaging items 7 to 9). The orthogonal dimensions represent a 45-degree rotation of the main pleasure-displeasure and activation-deactivation axes. Measures obtained on the PAND and PDNA dimensions may thus be converted to the pleasure-displeasure and activation-deactivation dimensions. They may also be converted to the positive feeling (PA) and negative feeling (NA) dimensions of PANAS (Watson et al., 1988). Friman et al. (2013) conducted a confirmatory factor analysis showing that the three STS measures (cognitive evaluation, positive activated-negative deactivated mood, and positive deactivated-negative activated mood) are distinct constructs positively correlated with each other and subsumed to a latent higher-order overall measure of satisfaction with travel. The measures had acceptable reliability, the measurement model was invariant across primary commute modes, and factor measures discriminated between the modes. The scale has been validated in several additional contexts finding support for its dimensionality (e.g., Glasgow et al., 2018). However, some have suggested that the dimensions measuring mood are slightly higher correlated for some travel modes, suggesting they merge to one factor (De Vos et al., 2015), and that the wordings of the adjectives need adjustment depending on language (Singleton, 2019).

In summary, STS may be used as a standardized retrospective measure of EWB during travel. The STS has adequate measurement properties, although improvements to individual items may be needed. In a recent validation study of STS in the US context, Singleton (2019) concluded that the scale is an effective summary measure of travel-related "hedonic subjective well-being". Although we concur with this conclusion, more studies are still needed of correlations between PAND and PDNA and measures of mood during travel. Also contributing to the validity would be studies correlating the STS scales with conventional measures of life satisfaction (e.g. Friman et al., 2017a; Olsson et al., 2013).

Table 2
The Satisfaction with travel scale (STS) (adapted after Ettema et al., 2011; Friman et al., 2013).

Cognitive evaluation
Travel was worst (-3) – best I can think of (3)
Travel was low (-3) - high standard (3)
Travel worked well (-3) – worked poorly (3)
Positive activation-negative deactivation
Tired (-3) – Alert (3)
Bored (-3) – Enthusiastic (3)
Fed up(-3) – Engaged (3)
Positive deactivation-negative activation
Hurried (-3) – Relaxed (3)
Worried (-3) – Confident (3)
Stressed (-3) – Calm (3)

Note. When administering the STS, items are presented in counterbalanced order.

5. Discussion and conclusions

An important tenet of this paper is that, in addition to influence satisfaction with travel, cognitive evaluations evoke emotional responses that in turn changes current moods. When aggregated over time, travel may therefore change emotional wellbeing (EWB) with potential broader wellbeing consequences (Diener and Chan, 2011; Kushlev et al., 2019; Martin-Maria, 2017). In order for this knowledge to have impacts on transport policy and planners, it is important to measure travel-related EWB and in this paper we have reviewed and assessed different measurement methods The methods we have assessed are complements to the traditional method of inferring satisfaction with travel from observed choices (Carse, 2011; De Vos et al., 2016), as well as to the method of measuring satisfaction with travel focusing on quality attributes (Redman et al., 2013).

We argue that emotional wellbeing should be assessed as current mood ("How do you feel now?"). This is also the most valid and reliable method since an instantaneous self-report measure is minimally influenced by memory distortions (Kahneman, 2001a, 2000b) as well as imposing a low response burden (Killingworth and Gilbert, 2010; Stone et al., 1999). However, since current mood may change during an extended travel episode, several measurements should be made and aggregated to assess travel-related emotional wellbeing. This raises the issue of whether in fact only a single retrospective measure of current moods is feasible in many applications. Therefore, we suggest that additional future methodological research investigates the relationship between retrospective measures and aggregated instantaneous measures of current mood.

It is also important to measure current mood before and after travel (Friman et al., 2013; Glasgow et al., 2018, 2019) to be able to infer effects of travel. This has unfortunately seldom been made in travel behavior research. Such measurements also need to use experimental or quasi-experimental designs to allow inferences of travel-specific effects.

A general conclusion is that current travel behavior research has started to attend to how travel is related to feelings, but that methods of measuring travel-related EWB need to be further developed and standardized. Additional research should investigate what factors evoke emotional responses during travel, how and to which degree the emotional responses influence current moods. This requires that methods of measuring feelings during travel (e.g., Dunlop et al., 2014; Raveau et al., 2016) or retrospectively (Kahneman et al., 2004) are developed, evaluated, and used. A specific gap of knowledge we observed is that no research has investigated anticipated mood, that is how people expect to feel during travel. It does not seem far-fetched to believe that when people make choices of travel mode, departure time, and travel time, they also take into account their anticipation of how they will feel during and after travel.

Declaration of competing interest

None of the authors have any conflict of interest.

CRediT authorship contribution statement

Tommy Gärling: Writing - original draft. **Dick Ettema:** Writing - original draft. **Filip Fors Connolly:** Writing - original draft. **Margareta Friman:** Writing - original draft. **Lars E. Olsson:** Writing - original draft.

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