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Travel and residual emotional well-being

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This study addresses the question of how work commutes change positive versus negative and active versus passive mood experienced after the commutes. Analyses are presented for 230 time-sampled morning commutes to work, made by 146 randomly sampled people in three different Swedish cities, asking them to use smartphones to report mood before, directly after, and later in the work place after the commute. The results show that self-reported positive emotional responses evoked by critical incidents are related to mood changes directly after the commute but not later in the day. It is also shown that satisfaction with the commute, measured retrospectively, is related to travel mode, travel time, as well as both positive and negative emotional responses to critical incidents.

1. Introduction

Over the past years an increasing number of studies have investigated satisfaction with travel (for reviews, see De Vos, Schwanen, Van Acker, & Witlox, 2013; Ettema, Gärling, Friman, & Olsson, 2016). In these studies retrospective measurement of satisfaction is made by means of self-report ratings some time after the destination of travel has been reached. The self-report ratings are either made of overall satisfaction on a single scale (e.g. Abou-Zeid & Ben-Akiva, 2010) or on multiple scales measuring affect and cognitive-evaluation dimensions of satisfaction (e.g. Friman, Fujii, Ettema, Gärling, & Olsson, 2013). The results show that satisfaction with travel is influenced by travel mode, travel time, crowdedness/congestion, social interaction during travel, solitary activities during travel, and weather conditions.

An issue not frequently addressed in this research is how travel affects changes in emotional well-being (EWB), measured as the balance of positive and negative affect that people experience in their everyday lives, which is regarded as the affective component of subjective well-being (SWB; Diener, Suh, Lucas, & Smith, 1999). A large current research literature (Diener et al., 1999; Dolan, Peasgood, & White, 2008) shows that EWB is important for people's life satisfaction. Evidence is also accumulating that EWB has non-trivial effects on morbidity and mortality (Diener & Chan, 2011). While EWB is affected by many other factors, positive or negative travel experiences may also have effects. It is therefore essential for transport policy making and planning that knowledge is acquired of how EWB is affected by travel, in particular by commuting to work as world-wide billions of people do every weekday.

A limited number of studies (discussed in the next section) have investigated effects of travel on retrospective measures of EWB, that is average reported duration or frequency and intensity of affect experienced during a past time interval. Yet,

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neither of these studies isolate the effects of travel from other effects, nor do they investigate how the effects of travel on EWB develop over time after travel. The empirical study presented in this paper measures travel-related residual changes in EWB by asking participants to report how they feel directly before and directly after a time-sampled morning commute to work and later after the commute. Our argument is that by focusing on EWB (also referred to as mood in this paper) on a short time scale, we more validly assess the effects of travel on EWB than measures of satisfaction with travel would do. We also measure satisfaction with the commute retrospectively to investigate differences in results compared to our measures of EWB.

In the next section we review previous studies investigating the effects of travel on retrospectively measured EWB and satisfaction with travel. This is followed by a conceptualization of our alternative approach to measure mood before and after travel. Aims, hypotheses, and method of the empirical study are then presented, followed by a description and discussion of the results. The final section discusses the implications of the results and charts avenues for further research.

2. Review of previous research

2.1. Emotional Well-Being

In measurements of instantaneous EWB (Killingworth & Gilbert, 2010; Stone, Shiffman, & DeVries, 1999), people report the degree of positive and negative affect during a specified activity or at a sampled point in time. Conventional self-report rating scales such as the *Positive Affect and Negative Affect Scale* (PANAS, Watson, Wiese, Vaidya, & Tellegen, 1999) or the *Swedish Core Affect Scale* (SCAS, Västfjäll, Friman, Gärling, & Kleiner, 2002; Västfjäll & Gärling, 2007) have been used to both instantaneously and retrospectively measure positive and negative affect. In retrospective measurements, the remembered frequency or duration and intensity of positive and negative affect during a past time interval are reported. The affect balance is a common index of EWB obtained by aggregating repeated ratings, such as the ratio of the frequencies of positive and negative affect (Diener, Sandvik, & Pavot, 1991), the difference between the average intensity of positive affect and the average intensity of negative affect (Kahneman, Krueger, Schkade, Schwarz, & Stone, 2004), or the difference between duration-weighted positive and negative affect intensities (Krueger & Schkade, 2008).

Emotional responses evoked by travel would potentially influence the affect balance. In Kahneman et al. (2004) commuting was found to be less associated with positive affect and more associated with negative affect in retrospective measures of emotional responses, when compared to other activities. Yet, the overall evaluation of the commute was positive. Morris and Guerra (2015a) analyzed travel data from a large US sample, where a retrospective aggregated measure had been obtained of mood (based on 0-to-6 ratings of happiness, sadness, tiredness, pain, and stress) during the preceding day. Excluding purely recreational travel, the results showed that daily travel only accounted for a few percent of the variance in mood. This was still not a trivial effect compared to several other activities included in the same study. Stone and Schneider (2016) found that commuting episodes during a day were rated high in stress and tiredness, but low in meaningfulness compared to other activities on the same day. Commutes to work were found to have less negative effects on tiredness than commutes home, while longer commutes were found to increase stress and tiredness. Jakobsson Bergstad et al. (2011, 2012) showed a direct effect of satisfaction with travel on a retrospective measure of the weekly affect balance as well as an indirect effect through self-reported affect associated with performance of frequent travel-related out-of-home activities during the week. Olsson, Gärling, Ettema, Friman, and Fujii (2013) found that retrospectively self-reported positive affect decreased with the duration of work commutes. Morris and Guerra (2015b) confirmed the negative association between travel time and mood, primarily because of increased stress, fatigue, and sadness on long trips. Feng and Boyle (2014) analyzed data from a large-scale British study concluding that long work commutes are more strongly associated with negative mood for women than men. A higher load of household duties and more trip chaining were proposed explanations of the observed sex difference. Humphries, Goodman, and Ogilvie (2013) failed however to find any relationship between commuting by physically active modes and mood.

2.2. Satisfaction with travel

The previous research thus suggests that one determinant of EWB is daily travel and its characteristics. Travel conditions also influence the evaluation of travel itself. To measure this we developed the *Satisfaction with Travel Scale* (STS) (Ettema et al., 2011; Friman et al., 2013). The STS entails nine self-report rating scales that may be applied to any mode of travel to retrospectively measure affect or mood during travel as well as a cognitive evaluation of the quality of travel (Ettema et al., 2011; Friman et al., 2013). Affect or mood as measured in STS varies along two dimensions that are orthogonal to each other and oblique to the valence and activation dimensions in SCAS (Västfjäll & Gärling, 2007; Västfjäll et al., 2002), one ranging from positive activation (positive valence, high activation) to negative deactivation (negative valence, low activation) and the other from positive deactivation (positive valence, low activation) to negative activation (negative valence, high activation). Friman et al. (2013) argued that the affect dimensions as defined in STS measure the most common categories of mood or affect (e.g. stressed, relaxed, bored, enthusiastic) during travel. Some studies (e.g. De Vos, Schwanen, Van Acker, & Witlox, 2015; Ettema et al., 2011) have found that the affect dimensions of the STS are positively correlated. This should not be interpreted such that the dimensions measure the same theoretical construct, but that they correlate when measuring satisfaction with a particular object. In retrospect an object such as a trip may, for instance, both be assessed as having induced a relaxing and an enthusiastic mood.

We emphasize that the measurement of mood during travel by the STS conceptually differs from the effect travel has on EWB following travel. First, the targeted time interval differs (during travel versus following travel). In addition, the questions in the STS explicitly refer to how one felt during travel, whereas measurement of EWB following travel refers to mood at the time of measurement. Measures of EWB following travel is most likely influenced by a potentially wide variety of factors, of which travel is only one.

In addressing the question of how satisfaction is influenced by travel, our conjecture is that critical incidents play a decisive role. Critical incidents refer to experienced episodes that are cognitively evaluated as negative or positive (Bitner, Booms, & Mohr, 1990; Gremler, 2004) and that may evoke emotional responses (Friman, 2004). Examples from studies of public transport include primarily negative critical incidents such as inappropriate treatment by employees, delays, travel information that is vague, inaccessible or incorrect, and inadequate design of vehicles, equipment or stops (Friman & Gärling, 2001). Such critical incidents during travel may influence retrospective affect or mood. Formally,

$$E_{n+1} = \frac{1}{n}\sum_{i=1}^{n}\left[w\left(\frac{i-1}{n-1}\right)^{s} + (1-w)\left(\frac{n-i}{n-1}\right)^{s}\right]dERCI_i \quad 0 \leqslant d,\ w \leqslant 1;\ s > 1, \tag{1}$$

where i (i = 1, 2, ... n) is time-ordered stages of a trip, E_{n+1} is the overall evaluation or satisfaction with the trip at time $n + 1$, $ERCI_i$ that varies from negative to positive, is a cognitive evaluation of a critical incident evoking an emotional response at time i during the trip, and d a memory-decay parameter representing that the cognitive evaluation or the emotional response may not be accurately remembered. The parameter $s > 1$ takes into account that the beginning and end are usually remembered better than the middle and, *ceteris parabus*, should therefore have more impact on satisfaction. The parameter w captures differences in primacy and recency effects in free recall (Davelaar, Goshen-Gottstein, Ashkenazi, Haarmann, & Usher, 2005), implying that the end and beginning are not remembered equally well and thus have different impacts.

Eq. (1) entails an averaging aggregation rule (e.g., Cojuharenco & Ryvkin, 2008; Seta, Haire, & Seta, 2008). Frequent deviations from this rule have been observed in studies demonstrating the peak-end aggregation rule (e.g., Ariely, 1998; Schreiber & Kahneman, 2000) according to which the final outcome (end) and the most intense outcome (peak or bottom) are averaged such that they receive disproportionately large impacts on the evaluation of the sequence. The peak-end rule is a special case of Eq. (1) (where $d > 0$ only for the last and best or worst outcome). It should however be noted that when measurements are made of complex sequences of real-life events (Miron-Shatz, 2009), possibly because memory of all events is retrievable, the peak-end rule provides a worse fit than aggregation rules. Likewise, Suzuki et al. (2014) found that overall satisfaction with work commutes is closely related to the average of satisfaction with each stage of the commutes weighted by its duration.

Travel is also cognitively evaluated as being of a good or bad quality. If critical incidents are encountered repeatedly, memory of their frequency would result in a cognitive evaluation of trip characteristics (Friman, Edvardsson, & Gärling, 2001; Friman & Gärling, 2001). A bus that frequently is delayed evokes a negative critical incident each time it is encountered and over time a cognitive evaluation of the service is developed as being unreliable. This will then influence the overall evaluation negatively. Additional characteristics of trips, for instance cost, may be cognitively evaluated on the basis of other information than previous experiences of the trip. Thus, the cognitive evaluation of public transport has been found to be related to cost, travel time, and punctuality (Beirão & Sarsfield Cabral, 2007; Fellesson & Friman, 2008; Friman & Gärling, 2001; Hensher, Stopher, & Bullock, 2003). Cognitive evaluations of car use are related to speed, flexibility, and convenience (Steg, Vlek, & Slotegraaf, 2001), while cognitive evaluations of cycling and walking are associated with safety, physical effort, and travel time (Pucher & Buheler, 2008; Rietveld & Daniel, 2004).

3. Conceptualization of residual mood effects of travel

Emotion is generally considered to be a multi-facet human experience. Several approaches are pursued in the vast literature on the topic (for a historical overview, see e.g. Feldman Barret, 2017). Our point of departure is Russell's (2003, 2014) psychological-construction theory in which emotional states are proposed to be constructed from simpler ingredients. A central ingredient is core affect, defined as "a neurophysiological state consciously accessible as the simplest raw (non-reflective) feelings evident in moods and emotions" (Russell, 2003, p. 148). Core affects are always accessible, either being neutral or having any other value in a dimensional system defined by the orthogonal axes pleasure-displeasure (valence) and activation-deactivation (activation or arousal) (Posner et al., 2009; Russell, 1980; Yik, Russell, & Steiger, 2011).

Mood is a prolonged core affect in Russell's (2003) theory. Hence, mood is always accessible and experienced as neutral or any combination of degrees of valence and activation. Several methods have been used to measure mood (Mauss & Robinson, 2009), although self-report ratings (e.g. Västfjäll et al., 2002) are by far the most common. In contrast to mood, an emotional response is consciously attended and causally attributed to an object, has a beginning and end, and is stronger than mood, which is a less transient emotional state residing in the background (Beedie, Terry, & Lane, 2005; Lazarus, 1991; Russell, 2003, 2014). An important, not yet theoretically fully resolved issue is whether and how emotional responses influence mood. Gärling, Ettema, Friman, and Olsson (unpublished manuscript) propose that changes in mood are related to emotional responses evoked by critical incidents as follows,

$$\mathrm{CM_i} = \begin{cases} \mathrm{CM_{i-1}} + (\mathrm{CM_{max}} - \mathrm{CM_{i-1}})(1 - \exp(-c_i\mathrm{ECI_i})) & \mathrm{EC_i} \geqslant 0;\ \mathrm{CM_{max}} > 0 \\ \mathrm{CM_{i-1}} - (\mathrm{CM_{i-1}} - \mathrm{CM_{min}})(1 - \exp(c_i\mathrm{ECI_i})) & \mathrm{EC_i} < 0;\ \mathrm{CM_{min}} < 0 \end{cases} \quad (2)$$

where CM_i is current mood at time i and CM_{i-1} mood at time $i-1$. Mood varies from maximally negative ($\mathrm{CM_{min}}$) to maximally positive ($\mathrm{CM_{max}}$). ECI_i denotes a positive-negative evaluation of a critical incident. If $c_i = 0$ the evaluation of the critical incident ($\mathrm{ECI_i}$) does not evoke an emotional response. If it evokes an emotional response, the degree to which it affects mood depends on how negative or positive the critical incident is evaluated and the value of the parameter c_i (>0) with a full impact on mood for $c_i = 1$. Emotional responses are, as noted above, unlikely to have a full impact such that mood changes profoundly.

Note that Eq. (2) implies that mood is unidimensional, whereas above we defined mood as a prolonged core affect that varies in valence and activation. Kuppens, Tuerlinckx, Russell, and Feldman Barret (2013) reviewed several models of how activation may be related to valence. Empirical support seems to weakly favor a V-shaped relationship, implying that activation increases with both positive valence and negative valence. This may reflect the activity of two brain systems; a positive appetite system and a negative aversive system (Watson, Clark, & Tellegen, 1988). Other research has demonstrated a weak positive linear correlation (e.g. Västfjäll & Gärling, 2007). Since it is unclear how valence and activation should be combined, we measure both mood dimensions and, since they may have different determinants (cf. Västfjäll & Gärling, 2002), we choose to model them separately.

Several studies have shown residual changes in mood after work commutes influencing performance. Schaeffer, Street, Singer, and Baum (1988) and Novaco, Stokols, Campbell, and Stokols (1979) found that negative stress due to automobile commuting resulted in errors in a subsequent proofreading task. White and Rotton (1998) reported negative stress effects of both automobile and bus commuting inferred from the commuters' reduced persistence in completing unsolvable puzzles. Yet another study of automobile commuting showed that annoyance due to longer distances and higher traffic congestion led to more negative evaluations of unqualified job candidates at the work place (Van Rooy, 2006). Wener, Evans, Phillips, and Nadler (2003) demonstrated that post-travel proof-reading performance was partially mediated by commuting time and presumably a negative mood during the commute. Improvements in public transport made people save time and, as a consequence, perform better. Hennessy (2008) showed that negative affect caused by automobile commuting had a spillover effect to work aggression.

Evidence also suggests that not only the factors specified in Eq. (1) influence retrospective evaluations of travel but that current mood at the time of evaluation may also do this (Schwarz & Strack, 1999). In Eq. (3) we therefore add a parameter v to represent the weight of this influence:

$$E^*_{n+1} = (1 - v)CM_n + vE_{n+1} \quad 0 \leqslant v \leqslant 1 \quad (3)$$

v would increase with the degree of retrieval from memory, thus being independent of whether the retrieved information is accurate or not. In an extreme case when $v = 0$, a traveler would be unable to retrieve any information about a trip, but instead report current mood when asked to evaluate satisfaction with the trip.

4. The empirical study

4.1. Aims and hypotheses

In our conceptualization we propose that mood is changed due to positive or negative emotional responses evoked by critical incidents during travel. Therefore, our primary aim in the present study is to investigate whether travel has residual effects on mood that are related to emotional responses to critical incidents. We obtain self-reports of mood before, directly after, and 1 h after a commute to work (see Fig. 1).

A secondary aim is to investigate how residual mood differs from satisfaction with travel. The STS is therefore used to retrospectively obtain measures of satisfaction with the commutes. Additionally, participants are asked to retrospectively report emotional responses to critical incidents and characteristics of the commutes such that analyses can be made of their relationships to residual mood and satisfaction.

We propose the following specific hypotheses: (H1) As implied by Eq. (2), critical incidents whose evaluations evoke emotional responses during travel would change mood immediately after travel in a positive or negative direction; (H2) Another implication of mood updating as modeled by Eq. (2) is that the effects of travel on mood would change over time if emotional responses occur after travel. If controlling for such non-travel influences on mood, we expect to observe remaining mood effects of travel in the work place later in the day; (H3) As implied by Eq. (1), critical incidents whose evaluations evoke emotional responses are expected to have impacts on the affect dimensions of the STS; (H4) As specified in Eq. (3), mood immediately after the commute would influence the affect dimensions of the STS; (H5) Commute characteristics have effects on the cognitive-evaluation dimension of the STS.

4.2. Method

4.2.1. Sample

A recruitment company initially contacted 2000 by phone interviews of which 360 agreed to participate and 231 eventually installed MyExperience. Those who were contacted were randomly selected from three urban areas in Sweden

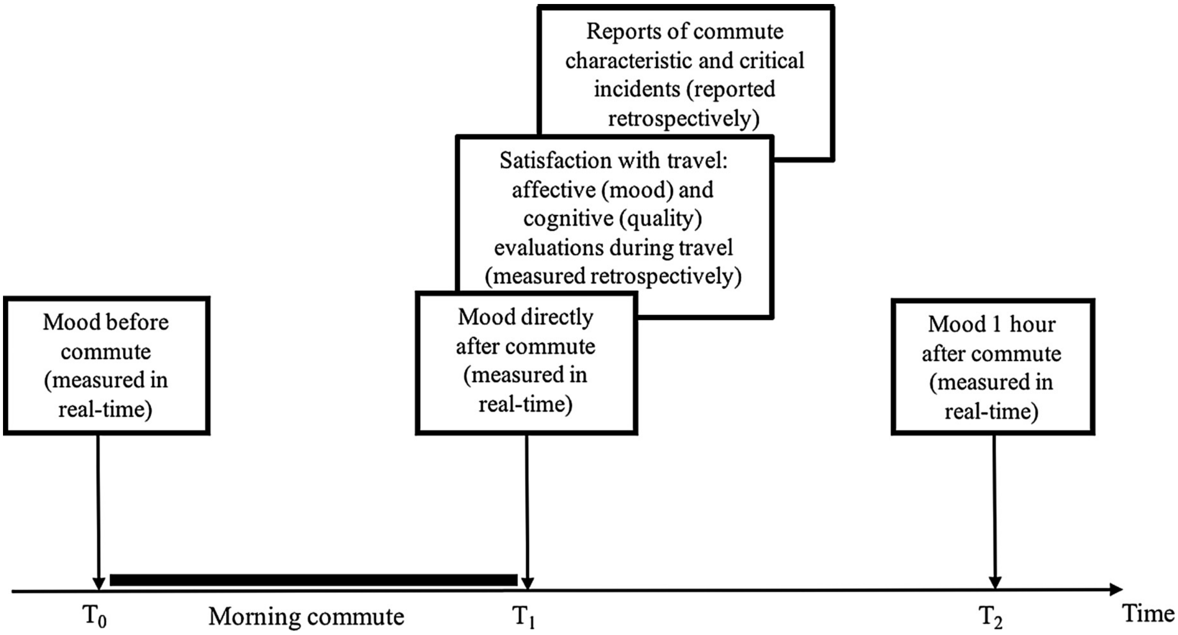

Fig. 1. Measures made before and after a morning commute to work.

(Stockholm, pop. appr. 1.400,000; Göteborg, pop. appr. 750,000; Karlstad, pop. appr. 100,000). Sampling was stratified such that equal numbers would be obtained from each urban area for the primary modes of car, public transport, and cycling or walking, and sex. Sample descriptives are given in Table 1 for 146 participants who remained after exclusion (as detailed below). Participants were recruited one or two weeks before the planned data collection, which took place during the last two weeks of November and the first week of December 2014. The weather conditions were normal for the time of the year with morning temperatures varying between −2.7 °C and 10.2 °C (Stockholm between 0.2 °C and 7.0 °C; Göteborg between 0.2 °C and 10.2 °C; Karlstad between −2.7 °C and 6.9 °C), daylight starting around 8:43 am and ending around 3:09 pm. These numbers are for the last day of the data collection period (December, 5). The daylight was approximately 50 min longer at mid-November for all cities, and started and ended 20 min earlier in Stockholm than in the other two cities. It was raining during four days.

Participants were required to have access to an iPhone or Android smartphone, to have downloaded the smartphone application "MyExperience" from AppStore or Google Play, and to have planned to travel to work at least two days during the following two weeks. The participants were asked to complete three questionnaires on each of the two travel days (1–2 min/questionnaire) and a follow-up questionnaire sent by e-mail (about 5 min) after the smartphone questionnaires were completed the last day. They received in compensation a multi-use voucher worth 100 Swedish Crowns (approximately USD

Table 1
Sample descriptives.

	Stockholm (Large)	Göteborg (Medium)	Karlstad (Small)	Mean
Number of participants	47	46	53	146[a]
Number of commute trips	73	71	86	230[a]
Women (%)	39.6	62.2	56.6	53.0
Age in years (M/Sd)	39.7/12.7	41.5/12.2	38.0/15.2	39.6/15.2
Household composition (%)				
Single household without children	27.1	13.3	17.0	19.2
Single household with children	2.1	11.1	1.9	4.8
Cohabiting household without children	14.6	8.9	17.0	13.7
Cohabiting household with children	39.6	37.8	45.3	41.1
Missing (%)	16.7	28.9	18.9	21.2
Income (%)				
<30,000 SEK[b]	25.0	24.5	35.9	28.8
30,000–39,000 SEK	20.8	26.6	33.9	27.4
≥40,000 < SEK	35.4	17.8	13.2	21.9
Missing (%)	18.8	31.1	17.0	21.9

[a] Sums.
[b] SEK (Swedish Crowns) approximately equal to USD 0.125.

15.00). In total the participants' workload was about 3 min to install and register in the smartphone application and about 15 min to answer the questionnaires.

4.2.2. Procedure

In the recruitment interviews participants were given instructions for how to download MyExperience that was later used to send questionnaires to their smartphones at different times during the two commute days. The smartphone application was also used to record participants' trips by GPS. Participants themselves administered the GPS by clicking on a "start trip" button in MyExperience when leaving home in the morning, and an "end trip" button when arriving at work. This option was offered to minimize battery use and allow participants to decide when they wanted to be monitored. The GPS data provided by the participants were however not analyzed because of its incompleteness.

Participants reported in the recruitment interviews which days they would commute to work during the following two weeks, the modes they would use, approximate departure times, and commute durations. This information was used to decide on which two days during one of the weeks and at what time to distribute the questionnaires during these days. Questionnaires were sent on three occasions during the day; at time T_0 30–60 min before their own estimated departure time of the morning commute, at time T_1 directly after the commute (estimated departure time plus estimated commute duration), and at time T_2 1 h after T_1. The participants were notified when a new questionnaire was available, along with information about when to answer it. If participants did not answer the questionnaire, a reminder was sent 30 min after T_0 and T_1 and 1 h after T_2. Each question was answered on a separate page in MyExperience. A marker indicated the proportion of questions that had been completed. Fig. 2 shows examples of how the different questions (translated from Swedish) were posed in MyExperience. As shown in the upper row, ratings of current mood and travel satisfaction were made by moving a slider from left to right. The rating was given by stopping when the appropriate number (from −3 to 3) appeared above the slider.

The follow-up survey sent by e-mail included questions about income, household composition, age, sex, travel-mode habits, experience with travel in general, emotional well-being during the last month, and overall life satisfaction. Only answers to the socio-demographic questions are reported here.

4.2.3. Measures

Mood. The question "*How do you feel right now?*" was answered by ratings on two bipolar 7-point scales adapted from Västfjäll et al. (2002) and Västfjäll and Gärling (2007), one measuring valence of mood with the left end-point "*Very sad, depressed, displeased*" (−3) and the right end-point "*Very glad, joyful, pleased*" (3), the other measuring activation of mood with the left end-point "*Very passive, sleepy, dull*" (−3) and the right end-point "*Very active, awake, peppy*" (3) with 0 a neutral point. The mood ratings were made at time T_0, T_1, and T_2, always before answering any other questions.

Satisfaction with travel. A shortened STS[1] (Friman et al., 2013) with three scales was used to measure travel satisfaction. Each scale was defined by the three pairs of end-point statements that in the STS define three separate scales. The question "*How did you experience your trip?*" was posed and answered by ratings on bipolar 7-point scales from −3 to 3; the first scale tapping the cognitive evaluation (CE) with the left end-point jointly defined by "*The trip worked very poorly, held low standard, was the worst imaginable*" and the right end-point jointly defined by "*The trip worked very well, held high standard, was the best imaginable*", the second scale tapping the affective experience of enthusiasm versus boredom (Positive Affect and Negative Deactivation or PAND) with the left end-point jointly defined by "*I felt very bored, tired, fed-up*" and the right end-point jointly defined by "*I felt very enthusiastic, alert, engaged*", and the third scale tapping the affective experience of relaxation versus stress (Positive Deactivation and Negative Activation or PDNA) with the left end-point jointly defined by "*I felt very stressed, worried, hurried*" and the right end-point jointly defined by "*I felt very relaxed, calm, confident*". The STS was administered directly after the mood ratings and only at time T_1.

Commute characteristics. At time T_1 questions were last asked about the commute. Participants indicated what primary mode they had used (car as driver, car as passenger, motorcycle, train, tram, subway, bus, cycle or walking with the possibility to add an additional mode if none was applicable). Furthermore, they reported duration of the total commute in minutes, any delays from expected arrival times in minutes, whether they were alone or accompanied by one or several family members, friends, or coworkers, and whether they had experienced any critical incidents evoking negative or positive emotional responses. If a critical incident had occurred, they specified its nature in an open-ended answer box for positive emotional responses and another for negative emotional responses.

Non-travel mood influences. At time T_2 a question was added to assess whether something unrelated to the morning commute had occurred between times T_1 and T_2 that changed the participants' mood. The question "*Has something occurred since you answered the questionnaire last time that made you feel differently?*" was answered by ratings on two bipolar 7-point scales from −3 to 3, one measuring changes in valence with the left end-point "*More sad, depressed, displeased*" and the right end-point "*More glad, joyful, pleased*", and one measuring changes in activation with the left end-point "*More passive, sleepy, dull*" and the right end-point "*More active, awake, peppy*". No change was indicated by choosing the mid-point (0) of the rating scale.

[1] Asking questions in a smartphone makes it necessary to decrease response burden. Therefore, we shortened the STS such that it consisted of only three scales with end-points defined by the adjectives that in the full-length STS are used to define the three scales for each dimension. Since the three scales used to measure each dimension in the STS have been shown to be strongly correlated (Friman et al., 2013), the shortened STS should not give different results. In indirect empirical support Västfjäll and Gärling (2007) found that shortening the SCAS in the same way gave almost identical results to the full-length scale.

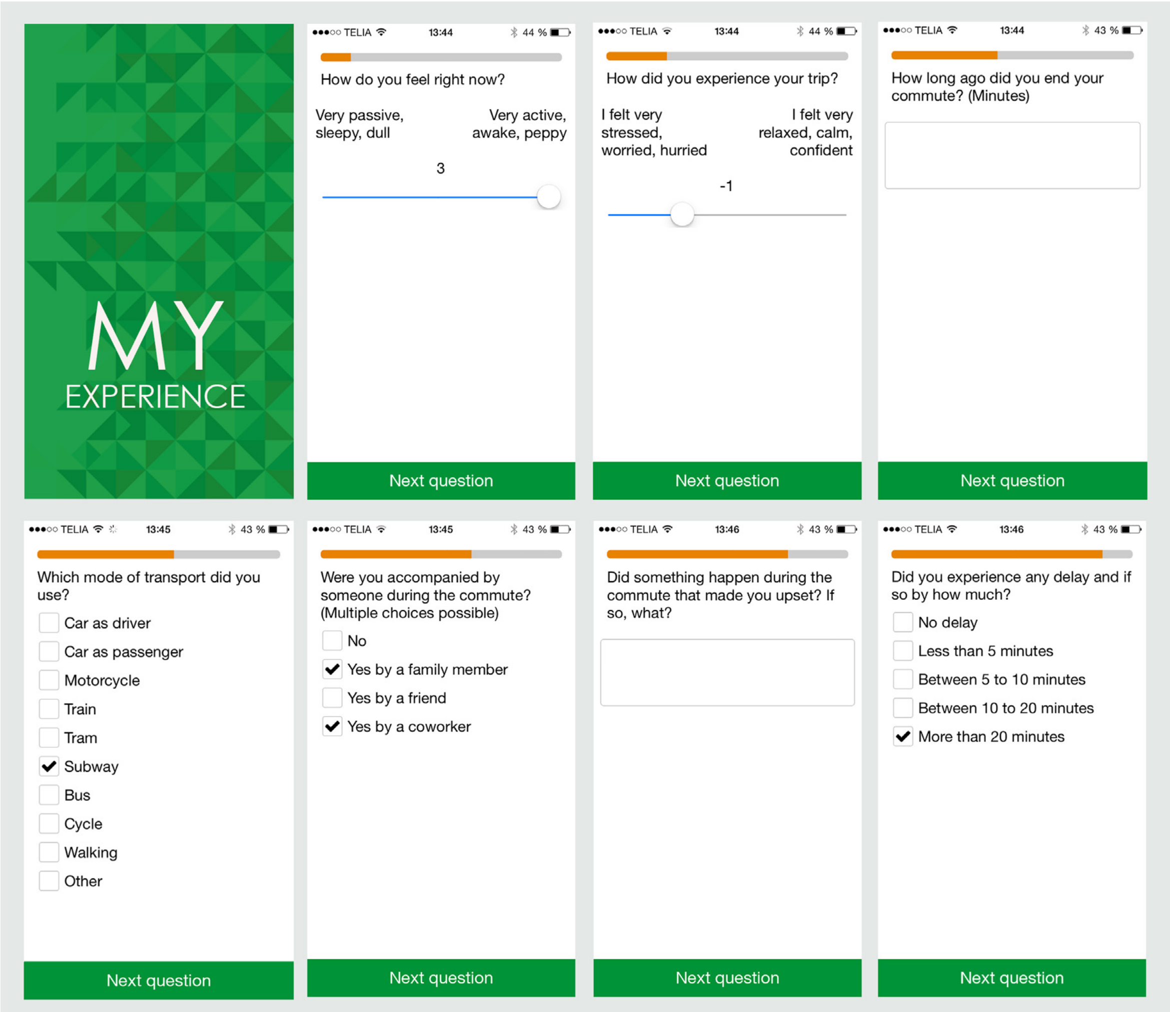

Fig. 2. Format of the questions posed in the "MyExperience" smartphone application. (Note that the questions were asked in the participants' native language Swedish. They were presented in the sequence as shown although due to space limitations one mood question, two STS questions, and the question about positive critical incidents are not shown. See Method for further explanation.)

4.3. Results

Some participants were removed from the subsequent analyses of the results since they did not complete the questionnaires or responded to the requests at the wrong time. In analyses of mood at T_1, observations are removed for those who responded to the questionnaire at T_0 after they had begun their commute and those who answered the questionnaire at T_1 either before their arrival or more than 60 min after their arrival. Furthermore, observations are removed from analyses at T_2 for those who responded more than 600 min after their arrival or less than 30 min after they responded to T_1. Seventy-nine participants then remained who responded at times T_0, T_1, and T_2 for two days, 49 participants who responded at T_0, T_1, and T_2 for one day, 5 participants who responded at T_0 and T_1 for two days, and 13 participants who responded at T_0 and T_1 for one day. In total, 146 participants answering questions related to 230 commutes were used. A large majority of the remaining commutes (216 or 93.9%) were reported to be made often or very often, and 14 (6.1%) rarely or never before. For 70% of the commutes participants responded at T_1 within 10 min after the commute, for 80% within 20 min, and for 90% within 40 min. Larger variation was observed at T_2 in that for 11% of the commutes participants responded within 60 min after the commute, for 54% within 120 min, and for 77% within 180 min.[2]

[2] In some cases it is possible that the questionnaires were answered at the requested time but that for some technical reason the data were received later. Another possibility is that participants answered the questionnaire when requested but forgot to directly press the submit button. In separate regression analyses response delay was not found to have significant effects on any of the dependent variables, neither at T1 or T2.

Table 2 gives mean, standard deviation, skewness, and kurtosis for each variable that will be used in multiple linear regression analyses. The product moment correlations between the variables are also reported. In the main diagonal are shown the correlations between the measures obtained for participants providing data for two days.

In the following subsections, we first report two separate regression analyses with the two measures (Valence and Activation) of mood immediately after the commute as the dependent variables, then another two separate regression analyses with the same two measures of mood obtained later at the work place as the dependent variables, and finally three separate regression analyses with the STS measures (CE, PAND, and PDNA) of satisfaction with the commute as dependent variables. We apply a fixed effects linear regression model, which takes the dependencies between repeated measures obtained for participants who reported mood or STS on multiple days into account. The fixed effects model includes two random terms to represent random variance across individuals and across all observations, respectively.

4.4. Residual mood effects

Table 2 shows that mean activation increased significantly from before (M = 0.49) to immediately after the commute (M = 1.13), $t(229) = 7.94$, $p < 0.001$, whereas mean valence increased significantly from immediately after the commute (M = 1.01) to later in the day (M = 1.20), $t(206) = 2.63$, $p = 0.009$. Thus, participants are on average more activated after the morning commute than before, but not more positive after than before.

In the regression analyses reported in Table 3 controlling for mood before the commute (Model 1), partial support is found for hypothesis H1 in that, as expected, critical incidents evoking positive emotional responses[3] influence both valence and activation after the commute. However, no effects are observed for negative critical incidents. In Table 4 a classification is presented of the recalled critical incidents by travel mode. As can be seen, weather dominates for positive critical incidents associated with non-motorized travel mode, whereas no category dominates for critical incidents associated with the other modes or negative critical incidents.

The effects on both valence and activation of positive critical incidents remained significant when commute characteristics are entered in Model 2 (Table 3). Delays marginally influenced activation. The total number of reported delays was 41 with 25 (61.0%) shorter than 5 min, 13 (31.7%) between 5 and 20 min and 3 (7.3%) longer than 20 min. Only a few were reported to result in a negative emotional response (categorized as "Reliability" in Table 4).

According to Hypothesis H2 we expected an effect on mood to remain later in the day after controlling for non-travel mood influences after the commute. Table 5 (Model 1) shows that when mood before (Valence and Activation at time T_0), mood immediately after the commute (Valence and Activation at time T_1), and non-travel mood influences between T_1 and T_2 are controlled, mood measured later in the day is no longer influenced by positive critical incidents during the commute. Thus, the hypothesis is not supported. When entering commute characteristic (Model 2) and traveler attributes (Model 3), travel time had a significant negative linear effect on valence and a marginally significant negative linear effect on activation. Travel time also had a positive quadratic effect on activation. Car versus public transport had a significant positive effect on activation.

In summary, we find partial support for hypothesis H1 in that critical incidents evoking positive emotional responses, but not those evoking negative emotional responses, influence changes in mood immediately after the commute. Yet, the correlations in Table 2 and the p values in Tables 3 and 5 suggest that mood before the commute had the strongest influence on mood immediately after the commute. Mood before the commute also had the strongest influence on valence later in the day, while mood immediately after the commute had the strongest influence on activation later in the day (Table 5). Hypothesis H2 is not supported, as only travel mode and travel time had effects on mood later in the day.

4.5. Effects on satisfaction with travel

Hypothesis H3 states that critical incidents evoking emotional responses are expected to influence the affect dimensions of the STS. In partial support of this hypothesis, Table 6 (Model 1) shows that both positive and negative critical incidents significantly influence feeling enthusiastic versus bored (STS-PAND), and that negative critical incidents also significantly influence feeling relaxed versus stressed (STS-PDNA). Furthermore, the results support hypothesis H5, stating that commute characteristics will have effects on the quality dimension of the STS (STS-CE). Compared to public transport, car significantly increases quality, whereas travel time and delays have significant negative effects on quality. Although not hypothesized, both positive and negative critical incidents significantly influence quality, and car mode and non-motorized mode significantly increase feeling enthusiastic versus bored.

The effects of commute characteristic remain significant when in Model 2 traveler attributes and mood immediately after the commute are entered. In support of hypothesis H4 stating that mood immediately after the commute may influence the affect dimensions of the STS, mood directly after the commute (activation) had a significant expected effect on feeling enthusiastic versus bored (STS-PAND), and valence of immediate mood a significant expected effect on feeling relaxed versus stressed (STS-PDNA). The effects of critical incidents are then reduced although still significant for negative critical incidents.

[3] Note that we asked participants to only report critical incidents that evoked positive or negative emotional responses. For simplicity we sometimes refer to positive or negative critical incidents instead of positive and negative emotional responses evoked by critical incidents.

Table 2
Response descriptives (n = 146 or 128 for traveler attributes, for all other variables measured at time T_0 and T_1 n = 230 and measured at T_2 n = 207).

	M	Sd	Skew	Kurtosis	Product moment correlations[a]								
					1	2	3	4	5	6	7	8	9
Traveler attributes													
1. Sex (men 1, women 0)	0.46	0.50	0.18	1.99	–								
2. Age (years)	40.12	13.32	0.10	−0.94	0.21[**]	–							
3. Age (years) squared	1786.33	1100.79	0.60	−0.55	0.22[**]	0.99[**]	–						
4. Small (1) vs. medium city (0)	0.37	0.48	0.52	−1.74	−0.01	−0.08	−0.04	–					
5. Large (1) vs. medium city (0)	0.32	0.47	0.79	−1.39	0.14[*]	0.01	−0.01	−0.53[**]	–				
Mood													
6. Valence T_0 (−3 to −3)	0.97	1.23	−0.32	−0.20	−0.18[**]	0.01	−0.01	−0.06	−0.01	***0.62***[**]			
7. Activation T_0 (−3 to −3)	0.49	1.47	−0.23	−0.79	−0.04	0.23[**]	0.20[**]	−0.01	−0.11	0.59[**]	***0.41***[**]		
8. Valence T_1 (−3 to −3)	1.01	1.20	−0.73	1.41	−0.15[*]	−0.01	−0.03	−0.07	−0.07	0.60[**]	0.47[**]	***0.44***[**]	
9. Activation T_1 (−3 to −3)	1.13	1.21	−0.70	0.84	−0.07	0.10	0.09	−0.09	−0.08	0.57[**]	0.60[**]	0.76[**]	***0.61***[**]
10. Valence T_2 (−3 to −3)	1.20	1.14	−0.77	1.32	−0.06	−0.04	−0.05	0.01	0.01	0.61[**]	0.34[**]	0.47[**]	0.39[**]
11. Activation T_2 (−3 to −3)	1.18	1.15	−0.57	0.51	0.04	0.15[*]	0.13	−0.03	−0.01	0.48[**]	0.48[**]	0.47[**]	0.55[**]
12. Influence valence $T_1 \rightarrow T_2$ (−3 to −3)	0.57	1.05	0.11	0.85	−0.06	−0.11	−0.10	−0.04	0.03	0.20[**]	0.05	0.19[**]	0.09
13. Influence activation $T_1 \rightarrow T_2$ (−3 to −3)	0.60	0.98	0.43	−0.04	0.00	−0.01	−0.03	−0.11	0.08	0.28[**]	0.13	0.23[**]	0.19[**]
Satisfaction with travel													
14. Bad (CE−) vs good quality (CE+) (−3 to −3)	1.44	1.11	−0.56	0.12	−0.13[*]	0.03	0.00	0.01	0.01	0.32[**]	0.24[**]	0.30[**]	0.23[**]
15. Bored (ND) vs enthusiastic (PA) (−3 to −3)	0.70	1.14	−0.18	−0.34	0.04	0.19[**]	0.17[*]	−0.07	−0.06	0.44[**]	0.49[**]	0.47[**]	0.60[**]
16. Stressed (NA) vs. relaxed (PD) (−3 to −3)	1.09	1.28	−0.73	0.29	−0.03	0.12	0.12	0.04	−0.08	0.26[**]	0.19[**]	0.35[**]	0.30[**]
Commute characteristics													
17. Car (1) vs. public transport (0)	0.32	0.47	0.77	−1.42	0.08	0.17[*]	0.14[*]	0.01	0.05	0.09	0.18[**]	0.02	−0.02
18. Non-motorized mode (1) vs. public transport (0)	0.32	0.47	0.77	−1.42	0.04	0.09	0.08	0.12	−0.07	0.03	0.07	0.06	0.14[*]
19. Travel time (minutes)	27.99	20.80	2.20	8.56	0.09	0.04	0.03	−0.23[**]	0.30[**]	−0.11	−0.17[*]	−0.10	−0.11
20. Travel time (minutes) squared	1213.98	2341.44	6.45	56.59	0.11	0.03	0.03	−0.14[*]	0.25[**]	−0.08	−0.17[*]	−0.12	−0.12
21. Delay (1) vs. no delay (0)	0.18	0.38	1.69	0.87	−0.09	−0.14[*]	−0.14[*]	0.02	−0.10	−0.09	−0.05	−0.16[*]	−0.14[*]
22. Company (1) vs. alone (0)	0.19	0.39	1.62	0.62	−0.08	−0.06	−0.06	0.07	0.08	−0.03	−0.05	−0.06	−0.08
23. Negative emotional response (yes 1, no 0)[b]	0.12	0.33	2.33	3.45	−0.05	0.03	0.04	0.02	−0.14[*]	−0.13[*]	−0.15[*]	−0.13	−0.13
24. Positive emotional response (yes 1, no 0)[b]	0.15	0.36	1.95	1.82	−0.07	0.07	0.07	−0.08	0.05	0.05	−0.02	0.17[*]	0.14[*]

	Product moment correlations														
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Mood															
10. Valence T_2 (−3 to −3)	***0.36***[**]														
11. Activation T_2 (−3 to −3)	0.66[**]	***0.50***[**]													
12. Influence valence T1 → T2 (−3 to −3)	0.41[**]	0.26[**]	***0.18***												
13. Influence activation T1 → T2 (−3 to −3)	0.30[**]	0.38[**]	0.56[**]	***0.36***[**]											
Satisfaction with travel															
14. Bad (STS CE−) vs good quality (STS CE+) (−3 to −3)	0.32[**]	0.22[**]	0.11	0.11	***0.39***[**]										
15. Bored (STS ND) vs enthusiastic (STS PA) (−3 to −3)	0.39[**]	0.49[**]	0.13	0.19[*]	0.40[**]	***0.49***[**]									
16. Stressed (STS NA) vs. relaxed (STS PD) (−3 to −3)	0.23[**]	0.11	−0.04	−0.01	0.39[**]	0.45[**]	***0.18***								
Commute characteries															
17. Car (1) vs. public transport (0)	0.05	0.17[*]	−0.02	0.06	0.22[**]	0.14[*]	0.14[*]	***0.95***[**]							
18. Non-motorized mode (1) vs. public transport (0)	0.02	0.09	−0.01	−0.01	−0.02	0.19[**]	−0.03	−0.47[**]	***0.82***[**]						
19. Travel time (minutes)	−0.16[*]	−0.12	−0.05	0.02	−0.14[*]	−0.23[**]	−0.12	−0.01	−0.29[**]	***0.75***[**]					
20. Travel time (minutes) squared	−0.13	−0.11	−0.05	0.02	−0.05	−0.17[**]	−0.07	−0.04	−0.21[**]	0.90[**]	***0.76***[**]				

(*continued on next page*)

Table 2 (*continued*)

	Product moment correlations														
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
21. Delay (1) vs. no delay (0)	−0.08	−0.04	−0.07	0.02	0.31**	−0.18**	−0.22**	−0.08	−0.05	0.12	0.07	***0.26****			
22. Company (1) vs. alone (0)	−0.02	−0.06	−0.09	−0.07	0.01	−0.08	0.01	0.29**	−0.16*	0.09	0.04	0.07	***0.60*****		
23. Negative emotional response (yes 1, no 0)[b]	−0.15*	−0.07	−0.06	−0.05	−0.40**	−0.23**	−0.31**	−0.06	0.03	0.07	0.01	0.31**	−0.01	***0.15***	
24. Positive response (yes 1, no 0)[b]	0.04	0.10	0.06	0.07	0.13	0.13*	0.07	−0.19**	0.25**	−0.02	−0.02	−0.10	−0.08	0.03	***0.25****

[a] In the main diagonal correlations (in italics and bold) are reported between day 1 and day 2 for those 128 participants who made ratings for two days.

[b] Evoked by critical incidents.

* $p < 0.01$

** $p < 0.001$.

Table 3
Regression analyses of mood measured immediately after commute (T_1) (n = 230).

	Valence time T_1 (−3 to −3)									Activation time T_1 (−3 to −3)								
	Model 1			Model 2			Model 3			Model 1			Model 2			Model 3		
	b	t	p	b	t	p	b	t	p	b	t	p	b	t	p	b	t	p
Independent variables																		
Commute characteristics																		
Negative emotional response (yes 1, no 0)[a]	−0.13	−0.66	0.512	−0.10	−0.47	0.641	−0.13	−0.61	0.545	−0.10	−0.53	0.594	−0.01	−0.07	0.942	−0.04	−0.20	0.842
Positive emotional response (yes 1, no 0)[a]	0.46	2.61	0.010	0.41	2.23	0.027	0.42	2.26	0.025	0.46	2.65	0.008	0.35	1.94	0.054	0.34	1.87	0.063
Car (1) vs. public transport (0)				−0.06	−0.36	0.720	−0.06	−0.31	0.756				−0.31	−1.68	0.095	−0.25	−1.27	0.205
Non-motorized (1) vs. public transport (0)				0.01	0.05	0.961	0.01	0.08	0.938				0.07	0.40	0.689	0.13	0.70	0.484
Travel time (minutes)				0.01	1.30	0.195	0.01	1.34	0.183				0.01	0.98	0.327	0.01	0.90	0.368
Travel time (minutes) squared				−0.00	−1.75	0.082	−0.00	−1.69	0.093				0.00	−1.13	0.258	−0.00	−0.98	0.328
Delay (1) vs. no delay (0)				−0.20	−1.15	0.251	−0.26	−1.44	0.153				−0.30	−1.72	0.088	−0.32	−1.84	0.067
Company (1) vs. alone (0)				−0.09	−0.51	0.613	−0.07	−0.42	0.675				−0.02	−0.13	0.900	−0.00	−0.01	0.989
Control variables																		
Prior mood																		
Valence T0 (−3 to −3)	0.56	10.59	<0.001	0.53	10.45	<0.001	0.53	9.84	<0.001									
Activation T0 (−3 to −3)										0.44	10.29	<0.001	0.45	10.21	<0.001	0.44	9.74	<0.001
Traveler attributes																		
Sex (men 1, women 0)							0.07	0.45	0.653							−0.05	−0.33	0.739
Age (yrs)							0.04	1.21	0.229							0.01	0.21	0.837
Age (yrs) squared							−0.00	−1.34	0.184							−0.00	−0.32	0.747
Small (1) vs. medium city (0)							−0.14	−0.79	0.433							−0.30	−1.65	0.102
Large (1) vs. medium city (0)							−0.28	−1.57	0.120							−0.30	−1.55	0.124
Adj R^2 fixed effects	0.36			0.35			0.35			0.32			0.32			0.32		

[a] Evoked by critical incidents.

Table 4
Classification of recalled critical incidents evoking positive and negative emotional response. (The categories reflect the common content of the reported critical incidents which participants described in more specific words.)

Category	Primary mode		
	Car (n = 74)	Public transport (n = 82)	Non-motorized (n = 74)
Positive emotional response			
Treatment by staff		2	
Seat available		2	
Nice fellow passengers		4	
Shorter route		1	
Exercise			4
Weather			13
Surroundings	1	1	2
Relaxation			2
Light traffic	2		1
Comfort and safety	1		
Sum	4	10	22
Negative emotional response			
Reliability		3	
Congested/Crowded	1	5	
Smell		1	
Fellow passengers		2	
Noise			1
Accident			3
Weather	2		2
Other drivers	3		1
Road conditions	1		3
Sum	7	11	10

In summary, the results differ slightly for satisfaction with travel than for changes in mood after the commute, since both positive and negative critical incidents, commute characteristics, and delays have significant effects. Partly as hypothesized, these factors have different effects on the cognitive-evaluation dimension compared to the affect dimensions of the STS. Also, the affect dimensions are, as hypothesized, influenced by mood after the commute. This influence reduced but did not eliminate the effects of critical incidents.

5. Discussion

Changes in mood after travel were hypothesized to be related to emotional responses evoked by critical incidents during travel (Friman & Gärling, 2001; Friman et al., 2001). To investigate this hypothesis we measured self-reported mood before and after morning commutes to work. A main finding is that mood changes immediately after the commute are related to reported positive emotional responses to critical incidents, but that the mood changes do not last until later in the day. Hence, the hypothesis that emotional responses to critical incidents affect mood after the trip is confirmed for positive although not for negative emotional responses, whereas the hypothesis that the travel-induced mood changes are maintained is refuted. The strongest effect on mood after the commute is mood measured before the commute. In this respect the results are consistent with previous research (e.g. Eid & Diener, 2004) demonstrating that mood (emotional well-being or EWB) tends to be relatively stable across time. The results are also in line with other research (Diener & Diener, 1996; Diener, Kanazawa, Suh, & Oishi, 2015) in showing that mood is on average positive.

As Table 4 shows, the reported positive critical incidents differ depending on travel mode. However, we do not find any direct effects of travel mode on the mood changes immediately after the commute (Table 3). Yet, Table 5 indicates that later in the day travel mode as well as travel time influence mood changes. Since these effects are not mediated by emotional responses to critical incidents, they may be after-effects (Hygge & Knez, 2001), for instance fatigue due to long commutes by public transport (e.g. Wener et al., 2003). An alternative interpretation that work influenced these mood changes should be ruled out by the control for self-reported mood changes due to other factors than the commute. Nevertheless, not only how mood changes influence work performance (Van Rooy, 2006), but also how work attitudes influence commute-related mood changes (Stone & Schneider, 2016) would be valuable to address in future research.

We also asked what the relationship is between retrospective measures of satisfaction with travel and measures of residual mood changes. Table 2 shows that the correlations between the STS and mood are positive. As Tables 3, 5, and 6 show, there are still important differences. In contrast to mood changes, satisfaction with the commute is influenced by both positive and negative emotional responses to critical incidents as well as by delays. The latter is however in most cases not experienced as negative. We also show that mood at the time of evaluating the commute influences the affective evaluations. As would be expected, this results in larger effects on satisfaction of emotional responses to critical incidents. Thus, the results

Table 5
Regression analyses of mood measured later after commute (T_2) (n = 207).

	Valence time T_2 (−3 to −3)									Activation time T_2 (−3 to −3)								
	Model 1			Model 2			Model 3			Model 1			Model 2			Model 3		
	B	t	p	B	T	p	b	t	p	b	t	p	b	t	p	b	t	p
Independent variables																		
Commute characteristic																		
Negative emotional response (yes 1, no 0)[a]	−0.19	−1.04	0.299	−0.14	−0.75	0.454	−0.12	−0.61	0.545	0.10	0.51	0.608	0.09	0.45	0.652	0.10	0.49	0.624
Positive emotional response (yes 1, no 0)[a]	−0.01	−0.03	0.973	0.00	0.02	0.987	0.02	0.09	0.932	0.10	0.54	0.586	0.11	0.61	0.546	0.11	0.59	0.555
Car (1) vs. public transport (0)				−0.09	−0.58	0.564	−0.10	−0.55	0.583				0.44	2.44	0.015	0.40	2.03	0.045
Non-motorized (1) vs. public transport (0)				−0.10	−0.63	0.527	−0.11	−0.63	0.533				0.20	1.13	0.260	0.17	0.90	0.369
Travel time (minutes)				−0.01	−2.16	0.032	−0.01	−2.03	0.044				−0.01	−1.81	0.072	−0.02	−2.08	0.054
Travel time (minutes) squared				0.00	1.56	0.120	0.00	1.51	0.132				0.00	1.91	0.058	0.00	2.06	0.039
Delay (1) vs. no delay (0)				−0.02	−0.10	0.921	0.01	0.05	0.961				0.08	0.46	0.648	0.09	0.54	0.593
Company (1) vs. alone (0)				0.12	0.76	0.449	0.11	0.69	0.490				−0.11	−0.65	0.516	−0.10	−0.54	0.589
Control variables																		
Prior mood																		
Valence T_0 (−3 to −3)	0.43	7.24	<0.001	0.42	6.94	<0.001	0.43	6.89	<0.001									
Activation T_0 (−3 to −3)										0.17	3.17	0.002	0.12	2.16	0.032	0.11	2.04	0.043
Valence T_1 (−3 to −3)	0.11	1.76	0.080	0.11	1.76	0.080	0.16	1.81	0.072									
Activation time T_1 (−3 to −3)										0.32	5.00	<0.001	0.34	5.22	<0.001	0.35	5.11	<0.001
Influence valence time $T_1 \rightarrow T_2$ (−3 to −3)	0.31	5.47	<0.001	0.31	5.39	<0.001	0.31	5.18	<0.001									
Influence activation time $T_1 \rightarrow T_2$ (−3 to −3)										0.33	5.08	<0.001	0.32	4.91	<0.001	0.32	4.84	<0.001
Traveler attributes																		
Sex (men 1, women 0)							−0.07	−0.54	0.592							−0.07	−0.47	0.638
Age (years)							−0.01	−0.37	0.713							0.01	0.15	0.878
Age (years) squared							0.00	0.37	0.712							0.00	−0.09	0.929
Small (1) vs. medium city (0)							0.11	0.70	0.485							0.02	0.12	0.903
Large (1) vs. medium city (0)							0.15	0.88	0.379							0.07	0.39	0.700
Adj R^2 fixed effects	0.45			0.43			0.42			0.38			0.37			0.35		

[a] Evoked by critical incidents.

Table 6
Regression analyses of the Satisfaction with Travel Scale (n = 230).

	Bad vs. good quality (−3 to −3)						Bored vs. enthusiastic (−3 to −3)						Stressed vs. relaxed (−3 to −3)					
	Model 1			Model 2			Model 1			Model 2			Model 1			Model 2		
	b	T	p	b	t	p	b	t	p	b	t	p	b	t	p	b	t	p
Independent variables																		
Commute characteristic																		
Car (1) vs. public transport (0)	0.54	3.17	0.002	0.53	2.87	0.005	0.70	3.55	<0.001	0.60	3.58	<0.001	0.35	1.67	0.097	0.30	1.43	0.155
Non-motorized (1) vs. public transport (0)	0.01	−0.05	0.958	−0.02	−0.11	0.910	0.58	2.98	0.003	0.46	2.74	0.007	−0.06	−0.27	0.788	−0.07	−0.33	0.746
Travel time (minutes)	−0.02	−2.70	0.007	−0.02	−2.68	0.008	0.01	−1.21	0.228	−0.01	−1.35	0.178	−0.01	−1.40	0.162	−0.01	−0.85	0.400
Travel time (minutes) square	0.00	2.31	0.022	0.00	2.22	0.028	0.00	0.37	0.715	0.00	0.72	0.472	0.00	0.93	0.352	0.00	0.69	0.494
Delay (1) vs. no delay (0)	−0.41	−2.31	0.022	−0.45	−2.53	0.012	−0.04	−0.19	0.854	0.04	0.26	0.794	−0.32	−1.43	0.154	−0.24	−1.13	0.262
Company (1) vs. alone (0)	−0.03	−0.18	0.861	−0.05	−0.31	0.761	−0.24	−1.25	0.213	−0.10	−0.61	0.545	0.00	−0.03	0.973	0.06	0.29	0.772
Negative emotional response (yes 1, no 0)[a]	−1.06	−5.25	<0.001	−1.06	−5.25	<0.001	−0.68	−3.23	0.001	−0.57	−3.05	0.003	−1.01	−3.91	<0.001	−0.98	−3.89	<0.001
Positive emotional response (yes 1, no 0)[a]	0.44	2.43	0.016	0.41	2.24	0.026	0.39	2.06	0.041	0.21	1.27	0.205	0.31	1.32	0.190	0.13	0.57	0.570
Control variables																		
Mood																		
Valence T_1 (−3 to −3)										0.03	0.42	0.678				0.27	2.64	0.009
Activation T_1 (−3 to −3)										0.45	5.94	<0.001				0.06	0.60	0.548
Traveler attributes																		
Sex (men 1, women 0)				0.36	2.55	0.012				−0.07	−0.56	0.576				0.07	0.44	0.659
Age (years)				0.04	1.34	0.183				0.01	0.34	0.736				−0.03	−0.72	0.470
Age (years) squared				−0.00	−1.34	0.182				−0.00	−0.12	0.908				0.00	0.99	0.321
Small (1) vs. medium city (0)				−0.05	−0.30	0.767				−0.25	−1.51	0.133				0.00	0.02	0.986
Large (1) vs. medium city (0)				−0.06	−0.31	0.761				−0.23	−1.37	0.171				−0.24	−1.18	0.237
Adj R^2 fixed effects	0.23			0.25			0.15			0.41			0.10			0.18		

[a] Evoked by critical incidents.

confirm our hypothesis that critical incidents influence the affect dimensions of the STS as well as the hypothesis that mood at the time of evaluation influences the affect dimensions of the STS. Furthermore, the results confirm the hypothesis that commute characteristics only influence the cognitive-evaluation dimension of STS. An unexpected finding was still that negative critical incidents influence satisfaction. A possible explanation is that when responses are made on the STS, people infer, based on general knowledge stored in memory, how they usually respond emotionally to critical incidents (Robinson & Clore, 2002). An example is delays that in general cause negative emotions. An alternative or complementary interpretation is that negative critical incidents did not affect residual mood changes because they were overridden by more recent critical incidents evoking positive emotional responses. Therefore, satisfaction but not residual mood changes were affected. In addition, implying the reverse causal direction, the positive mood we observed before the commute may be less affected by negative than positive critical incidents. This may also possibly explain why emotional responses to critical incidents influenced the cognitive-evaluation dimension.

Measuring satisfaction with travel immediately after the commute should be a more valid measure of the effects of travel on emotional well-being compared to retrospective evaluations. Our argument is based on research (e.g. Robinson & Clore, 2002) showing how stereotyped thinking (i.e., that people tend to think how things normally work) may cause memory distortions. Such memory distortions and others due to memory decay are likely to increase with how long time after travel measurements are made. When comparing the present results to our previous research (Ettema, Friman, Gärling, Olsson, & Fujii, 2012; Olsson et al., 2013; Suzuki et al., 2014) in which retrospective self-reports were obtained some longer time after daily commutes, we fail to find any important differences. This is not surprising, as the repetitive nature of work commutes would strengthen memory. In addition, in the previous studies we required participants to report the most recent normal commute which may have occurred the same day. An advantage of a smartphone study is still that it may make possible to better identify critical incidents. Travelers will in general be more likely to accurately recall critical incidents immediately following their commutes than later. It would be even better if critical incidents are recorded during the trip (Dunlop, Casello, & Doherty, 2015).

Several short-comings of a smartphone study also need to be recognized. Losing data for technical reasons, due to lack of supervision of responses, or a too high response burden is an obvious problem that we encountered. Furthermore, it is difficult to determine impacts of lost data. We recorded GPS data, but ethical rules did not permit us to force participants to accept this. Therefore, the incomplete GPS data we obtained were of less value. It is also a problem of making inferences from such data. In the future this possibility may improve significantly. For example according to Miller (2012), many companies are now developing bluetooth sensors that may be used to connect smartphones to external events recorded by other devices.

We need to consider possible reasons why we found small effects of the work commutes on residual mood changes. Note that small effects were also found by Morris and Guerra (2015a) when excluding recreational travel. A work commute is undertaken most days in most weeks of the year and does not vary substantially. The transportation system also operates smoothly most of the time. Critical incidents that evoke emotional responses are therefore unlikely to occur frequently. In Sweden the weather that varies substantially with season may still cause differences in work commutes from day to day, in particular during the winter which we however did not investigate in this study. Other travel than repetitive work commutes would conceivably also more strongly cause mood changes. This may even apply to commutes from work back home. Novaco, Kliewer, and Brouet (1991) found that home commutes may have negative effects on mood after arriving at home. The frequent dropouts from the random sample are another reason for concern about sampling biases. A resulting insufficient sample size does not affect effect sizes, but may have made some true effects statistically non-significant.

The question may finally be raised, regarding how mood effects are related to travel choice. Abou-Zeid and Ben-Akiva (2013) show how to incorporate post-travel satisfaction into choice models. However, if awareness is lacking about what causes residual mood changes, how can they then influence subsequent deliberate choices? It is plausible that if people remember how they felt (or usually feel) after commuting to work, they may, without knowing why, both complain about and want to make changes to their commute. For instance, they may want to change to a non-motorized travel mode, reduce commute time or change departure time. Whether mood changes play this role is another issue future research should address.

6. Implications

Our results show that emotional responses to critical incidents during work commutes have residual effects on mood after the commute. Although any definite specific policy recommendations based on these results are unripe, we still feel that the results boost the importance of transport policies targeting users' wellbeing. Furthermore, transport service providers realizing that negative and positive experiences during work commutes may impacts on users' satisfaction and mood may use this knowledge in service development to attract new users and ultimately to increase their market share. The new insight is that evoking positive emotional responses during travel not only increase satisfaction with travel but also a positive mood after the commute with wider consequences for performance of other activities (e.g., job satisfaction and job performance), for general emotional well-being, and in the prolongation for life satisfaction. A public transport example of how to increase positive emotional responses that boost a positive mood may be to provide media screens in waiting areas or at bus stops. Another example is "infotainment" systems in vehicles broadcasting positive messages (e.g., local history or events). Additional research consisting of intervention studies to validate such specific recommendations is needed.

Our study also raises general questions about how travelers' satisfaction should be measured. Are there any reasons to measure mood after travel? Or are retrospective measures of satisfaction with travel sufficient? Should measurements be made on-line during travel? We believe residual mood as a measure of effects of travel on emotional well-being should be an ultimate criterion and therefore important to consider in improving the transportation system. Yet, this does not exclude measuring satisfaction with travel, since it is important that people experience that the transport system has a high quality. It would also be desirable with on-line measures of emotional responses or mood during use of the service. Residual mood effects may be positive, although lower due to the occurrences of negative emotional responses during travel. Knowledge of these, such that they can be eliminated, would then increase a positive residual mood even further. By increasing a positive mood throughout the trip, the likelihood is increased that the work commute will be remembered positively and that commuters will spend more time thinking of positive instead of negative experiences. Quality improvements will not only increase satisfaction with travel, but also maintain travelers' initially positive mood.

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