How did I feel? Recalling reported core affect in light of its fluctuation, the present state, and individual degrees of neuroticism

A Master's Thesis

Author	Tim Tiede
Student Number	s1872958
Academic Year	2019/2020
First Supervisor	Dr. Matthijs L. Noordzij
Second Supervisor	Dr. Noortje Kloos
Institute	University of Twente
Faculty	Faculty of Behavioral, Management, and Social Sciences (BMS)
Program	Psychology, Master
Specialization	Positive Psychology and Technology (PPT)

Abstract

Individuals that are supposed to report their present state tend to remember a state differently than they initially reported when being asked a week later. This difference in reported and recalled state was found to be related to the person's condition at the time of the recall, the reported state's fluctuation before the recall, and the personality trait neuroticism. However, these findings mainly refer to the recall of pain, and have not been extended to core affect. Core affect is a two-dimensional measure of mood, consisting of arousal -how active the person feels- and valence -the state's pleasantness. Considering the importance of self-report of past feelings in psychodiagnostics, this study set out to investigate whether the recollection of own states of core affect is likewise affected by the present state, the fluctuation of core affect, and neuroticism. Individuals reported their momentary core affect six times per day over a period of one week. Subsequently, they tried to recall how they felt overall throughout that week. Correspondence between the reported and recalled core affect was measured, as well as the impact of the last measurement before the recall, the fluctuation of core affect, and neuroticism on the recalled core affect. The results revealed a strong relationship between momentary and retrospective measurements for arousal (r=.843, p< .01*)* and valence (r = .751, p< .01), with adequate correspondence between recalled and reported core affect. However, individuals systematically overestimated their reported arousal. Moreover, the fluctuation of valence was related to an underestimation of reported valence (B_1 = -1.208, t = -2.401, p = .026). Findings on the influence of the present state, the fluctuation of arousal, and neuroticism were not associated with recalled core affect and indicate that different factors affect the recall of core affect compared to strong arousing experiences such as pain.

How did I feel? Recalling reported core affect in light of its fluctuation, the present state, and individual degrees of neuroticism

In medical and psychotherapeutic practice, individuals are commonly asked to report their past and present condition for diagnostic purposes. Whereas in medicine the main focus lies on somatic complaints such as pain, psychology focuses on the subjective state of feelings, for instance reported in core affect- a measure of mood, or feelings, based on the pleasantness and the arousal of an individual's state (Russell, 2003). Research on self-reports of somatic complaints has found differences between the somatic symptoms that individuals reported to experience at a present moment and the symptoms that they later remembered to have experienced at that time in the past (e.g. Schuler et al., 2019). This phenomenon received much attention by research on somatic experience, and since the later recalled state appeared to differ systematically from that earlier reported, it is oftentimes referred to as recall bias (Walentynowicz, 2016). Several factors have been identified that systematically affect an individual's memory of own somatic symptoms; The individual's condition while recalling the past symptoms, the fluctuation of the somatic symptoms during the period that was being recalled, and the character trait neuroticism (Kikuchi et al., 2006; Meek, Lareau, & Anderson, 2001; Noel, Chambers, McGrath, Klein, & Stewart, 2012; Safer & Keuler, 2002; Safer, Levine, & Drapalski, 2002). The majority of studies investigated the role of these factors in relation to the recall of somatic experiences, not however core affect. It not only remains unclear whether core affect reported at a present moment tend to differ from those later recalled. Also, it is not known whether the state whilst recalling core affect, the fluctuation of core affect, and neuroticism have an impact on individuals' memory of past core affect. Considering the relevance of retrospective self-reports of own feelings in psychology, understanding if and how memory of own core affect is shaped allows to reconstruct and interpret past experience more accurately.

The goal of this study is not only to investigate how reliably individuals are able to recall how they felt in the past week, but also whether these the present state, the fluctuation, and the personality trait neuroticism affect the recall of core affect in the same way they have been found to affect the recall of somatic experiences.

Core affect

Core affect is a concept that represents an individual's affective state, commonly referred to as mood or feelings (Russell, Weiss, & Mendelsohn, 1989). It has been introduced by Russell

(2003) and consists of two dimensions: arousal, ranging from low to high, and valence, ranging from unpleasant to pleasant. Arousal represents an individual's active energy- accordingly, a sleepy person would be low in arousal. Valence, on the other hand, represents the pleasantness of the individual's affective state- a sad person would score low on valence (Russell, 2003). A one-item measure of core affect is the affect grid, a coordinate system with valence and arousal as horizontal and vertical axes, that requires the individual to set a mark in the area which represent the own affective state best (Russell et al., 1989). Varying versions of it are in use; A difference of the affect grid used in this study from other affect grids used in research is the use of the indicative terms *low arousal* and *high arousal* at the horizontal axis in place of the common distinction *sleepy* and *activated* (Russel, 2003). This decision refers to the potentially negative notion of the term sleepy that could lead to lexical priming, biasing an individual's judgement [for a comprehensive overview on lexical priming see Hoey (2012)]. Initially, the affect grid has been used to report static information of single instances such as affective qualities of facial expressions or emotion-related words (Russell et al., 1989). However, its quick and easy administration offers the opportunity to use the affect grid to investigate not only a single state, but the fluctuation of a dynamic, changing state such as individual mood. This can be done by means of repeated administration of the affect grid in short intervals (see Ebner-Priemer et al., 2015; Kuppens, Oravecz, & Tuerlinckx, 2010). This type of repetitive sampling behavior with a single measure is typically found in relation to the experience sampling method, ESM.

Experience Sampling

Experience sampling enables monitoring of dynamic subjective states, such as core affect, by letting the individual fill in short measures repetitively over a longer period of time (Palmier-Claus et al., 2011; Trull & Ebner-Priemer, 2013). Its popularity increased with growing interest in dynamic affective states, since the obtained data provides information about the subjective state at the moment of the measurement as well as the change it underwent from one to the next measurement (Schimmack, 2003). Apart from information about fluctuation, the experience sampling method allows to compare momentary reports of the affect grid with a later retrospective assessment, giving insight into the factors influencing the recall of subjective experience and their connection to recall biases.

Recall bias

In general, individuals who report subjective experiences such as pain exhibit systematic discrepancies between momentary and retrospective reporting that are referred to

as recall bias (Stone, Broderick, Shiffman, & Schwartz, 2004, Walentynowicz, 2016). This discrepancy is claimed to be caused by differences in encoding and recall. More precisely, Robinson and Clore (2002) concluded that individuals who provide a momentary report of their own state make use of their episodic memory- memory about specific events and situations. In contrast, retrospective recall is based on the individual's beliefs about oneself, which are part of the semantic memory- general knowledge and beliefs about the world, including oneself (Robinson & Clore, 2002). This is in line with the popular notion of an experiential self and remembering self, as introduced by D. Kahneman (2011). In practice, this means that retrospective reports differ from momentary reports due to reduced clarity of the factual memory about the event. The less clear the memory is, the more is the memory reconstructed based on general beliefs about oneself and the world (Robinson & Clore, 2002; Stone et al., 2004, Broderick et al., 2008).

Factors of Recall Bias

In support of this notion, research identified several factors that bias retrospective judgement. In other words, these factors influence the retrospective judgement that a person makes in a systematic way. Controlling for these factors could not only allow to better predict the outcome of a retrospective assessment, but also to understand an individual's recall in the light of their past experience. One factor that has been found to affect the recall of subjective experience is the present state, that skews the belief about the past state (Eich, Reeves, Jaeger, & Graff-Radford, 1986; Houtveen & Oei, 2007; Meek, Lareau, & Anderson, 2001).

Present State

Several studies indicated that retrospective judgement is affected by the individual's condition at the time of the recall. Meek et al. (2001) found the discrepancy between the previously reported and later recalled symptom intensity of obstructive pulmonary disease to be determined by the symptom intensity at the time of the recall. In line with this, Noel et al. (2012) found that a child's level of anxiety at the time of the recall predicted the retrospective overestimation of own experienced pain. Further support for the notion that the state around the time of the recall biases retrospective judgement was found in students, who underestimated their pre-test anxiety when they were informed to have obtained a good grade (Safer et al., 2002). Overall, these studies indicate that an individual's recall of experiences such as pain tends to be biased in a way that it corresponds with the quality of the present state. However, these studies focused mostly on somatic experiences and anxiety, and it is unclear whether the present state similarly influences the recall of general states of feelings as

measured by core affect. Another factor that has been identified to account for recall biases is the fluctuation of a state around the time that is being recalled.

Fluctuation

Another factor accountable for discrepancies in retrospective and concurrent ratings of own subjective experiences is the fluctuation between the time of the initial reporting and the recall. Sohl and Friedberg (2008) found an individual's recall of previously reported fatigue to be determined by the extent that their fatigue fluctuated during the time before the recall. Furthermore, research by Kikuchi et al. (2006) indicated that recall accuracy of reported headache was low especially in those individuals who's headache intensity changed most frequently over time. Likewise, Lefebvre and Keefe (2002) found individuals who recalled their pain to have fluctuated strongly to be less accurate in recalling pain intensity at a specific point in time. Taken together, the extent of fluctuation of a personal subjective state such as pain appears to affect the ability to accurately recall the quality of this state in the past. Here again no information exists on whether the fluctuation of own, general affective states as measured by core affect affects the outcome of later recall.

Finally, also an individual's personality has been related to biases in the recall of somatic experiences such as pain. More specifically, the character trait neuroticism is linked to a negative bias when retrospectively evaluating past experiences.

Neuroticism

Neuroticism is defined as tendency to display and respond with negative affectivity, manifested in sadness, anxiety, irritability, and self-consciousness (Costa & McCrae, 1987; Costa & McCrae, 1992; Lahey, 2009). Individuals with this trait have been found to overestimate the extent to which they experienced negative states such as pain in the past- this also applied to those individuals who characterized themselves as neurotic (Barrett, 1997; Safer & Keuler, 2002). According to Larsen (1992) a selective memory processing of neurotic individuals leads to negative symptom overreporting. Overall, an individual's extent of neuroticism appears to be connected to retrospective overestimation of negative states.

In sum, the condition at the time of recall, the fluctuation of a subjective state, and an individual's degree of neuroticism appear to account for differences between reported and recalled subjective states such as pain and fatigue. It remains open whether these factors likewise bias the recall of core affect. The present study is set out to address this gap of knowledge.

The present study

The goal of this experience sampling study is twofold: First, to examine how accurately individuals recall core affect which they reported over a period of one week. Secondly, to investigate whether factors found to account for the outcome of the recall of subjective states such as pain likewise affect the recall of core affect. Based on the aforementioned research, the hypotheses are as follows:

H1

For both, arousal and valence the relationship of the retrospective rating and the average core affect as represented in the average of all momentary ratings is moderate, with *r* of .55.

H2

The discrepancy between the reported and the recalled average core affect is large, indicated by a difference of at least 40 points in the affect grid.

H3

Core affect at the time of the recall, its fluctuation throughout the week, and the average core affect predict recalled core affect better than the momentary measurements only. The present state is positively associated with the retrospective recall, and the fluctuation negatively.

H4

The individual extent of neuroticism is associated with a retrospective underestimation of the past week's score on the facet valence.

Method

Design

In this single-group experience sampling-study the participants rated their momentary state of core affect six times per day over a period of seven days using their smartphone. This way, 42 concurrent measurements were obtained. At the end of this period the individuals were asked to assess their own overall core affect that they had experienced throughout the week of measurement. Before the testing period began the participants filled in a measure of neuroticism. To administer the measures and collect the data the author used a mobile application, Tiim- The incredible intervention Machine. TiiM is an IOS and Andriod-compatible app developed by the University of Twente. Via this app the participants received notifications and gained access to the measures, which could be filled in on the mobile phone.

The timing and order of the affect grids were controlled via the app. The data was saved in the interface of the app, from where it was accessible to the researcher. Ethical approval for the data collection was given in February 2019 by the ethics committee of the University of Twente.

Participants

52 participants took part in this research, all of which were reached out to through convenience sampling. Preconditions for an individual to take part in the study were English reading skills and a smartphone that was connected to the internet from 10am to 8pm each day. Out of the 52 participants, only 25 remained due to technical issues and too few completed affect grids. All of these 25 participants were students, with 19 females (64%), and 9 males. The age span was 18 to 25 years, with an average age of 21.60 (*SD* = 1.71). With 21 participants, the majority of the remaining individuals was German, 2 individuals were of Dutch origin, and 2 individuals from other nationalities. For the analyses including the neuroticism scale of those 25 only 19 individuals could be included (7 male, 12 female, M_{age} = 21.58, *SD* = 1.68, range = 18-25, 16 German, 3 other), as the app malfunctioned and did not transfer all participants' answers to the neuroticism scale.

Procedure

Before the execution of the study, pilot tests were conducted to evaluate the app's functioning. This decision is grounded in instructions by Conner and Lehman (2012). Every participant filled in an informed consent and was provided with information about the scope and general set-up of the study (see Appendix B). When individuals decided to participate, they received an account to access Tiim on their mobile phones. Throughout a one-week period every participant received six affect grids daily to fill in. The measurements took place every two hours, with the first affect grid of a day appearing at 10:00 am, and the last one at 8:00 pm. Every affect grid was introduced with a notification on the mobile phone reading "please indicate how you are feeling" (see Figure 1). The affect grid stayed available on the phone for one hour. After 30 minutes, the notification would appear on the screen for a second time, but only if the grid had not been filled in until that time. After one hour the affect grid disappeared, to make sure that the measurements lay at least one hour apart. At the end of the measurement period the participants were asked to fil in a final affect grid to indicate how they thought they felt in average throughout the week of measurement. This final affect grid was introduced with the notification 'Dear participant, this is the final affect

grid. Here, we would like you to indicate how you felt overall throughout the week of the intervention'. After filling in the final affect grid, the intervention ended.

Measures

The Neuroticism Scale

12 items of the Eysenck Personality Questionnaire-Revised Short Form [EPQR-S] measuring Neuroticism. The EPQR-S is a 48-item measure designed by Eysenck, Eysenck, and Barrett (1985) to assess an individual's neuroticism, extraversion, lying, and psychoticism. In this study only neuroticism was assessed. The items are listed in Appendix B.

Overall, the neuroticism scale of the EPQR-S showed good reliability with Cronbach's alpha of .80 for males and .84 for females when using a dichotomous question format (Eysenck et al., 1985). In the present study the items were presented in the form of a 5-point Likert-scale (1= strongly disagree, 2= slightly disagree, 3= neither agree nor disagree, 4= slightly agree, and 5= strongly agree). The neuroticism scale showed excellent internal reliability with Cronbach's alpha of .92 (Muñiz, García-Cueto, & Lozano, 2005). With regard to construct validity, the one-dimensional structure of the neuroticism scale has been confirmed repeatedly with around 37% explained variance by a single factor (Ferrando, 2001; Muñiz et al., 2005).

Measuring Core Affect

In the present study, the affect grid has was the measure of core affect. The affect grid used in the present study is depicted in Figure 1. The affect grid consists of a coordinate system with its axes representing valence (horizontal) and arousal (vertical). Valence represents the pleasantness of an individual's momentary mood, ranging from low, 'unpleasant', to high, 'pleasant". Arousal, representing the 'active energy' of the present state, ranging from 'low arousal'- e.g. in the case of sleepiness, to 'high arousal' (Russel, 2003). The point of the axes' crossing indicates a state of neutrality. The affect grid in the current study is custom made and uses a 100x100 coordinate-grid consisting of 10x10 squares with indication words at the axes' outer border.

The affect grid's psychometric properties were found to be good to adequate. It repeatedly has been shown to have high split-half reliability when rating emotional qualities of words and facial expressions (.97 in case of arousal, .98 regarding valence) (Russell et al., 1989). This was also the case in the present study, with split-half reliability of .80 for valence and .73 for arousal. In support of the two-dimensional structure, construct and convergent

validity have been found to be moderate to high, with values of .63 to .92 in case of arousal and .47 to .94 for valence (Killgore, 1998; Russell et al., 1989).

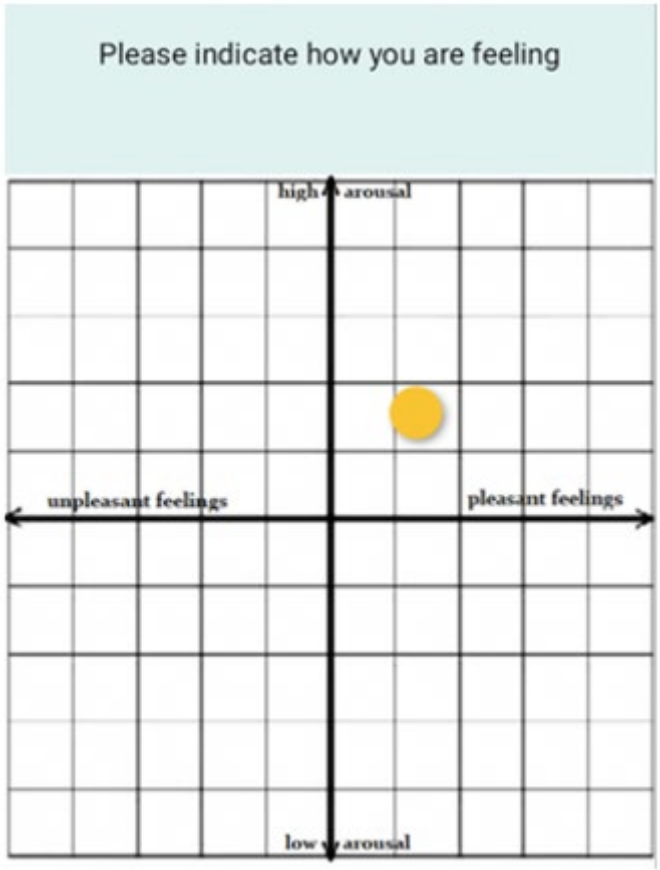

Figure 1. The affect grid of the current study with A score of 27/31 on valence and arousal, respectively.

Data Analysis

The data gathered from the momentary measurements and the questionnaires was transferred to SPSS for the analyses. The data of the participants was included in the analyses if they filled in at least 3 affect grids on at least 4 days. This was the case for 25 participants. The decision for this criterion is grounded in the finding by Broderick, Schwartz, Schneider, (2008) that averaging ratings of at least 3 days of a week reaches a .90 correlation with the average of ratings for all 7 days.

Each rating on the affect grid was captured with two distinct scores- one for valence and one for arousal. The individual means and standard deviations were obtained using linear mixed model analysis. Before the analyses, the data was tested and found to be normally distributed.

Relationship between concurrent and retrospective reports

To investigate the relationship between the concurrent and the retrospective reports the author conducted a correlational analysis with the average core affect of the momentary measurements and the recalled core affect. Based on recommendations by Cohen (1992), a correlation between 0 and [-].3 was considered to be very weak, a correlation between [-].3 and [-].5 was considered to be moderate, [-].5 and [-].9 to be strong, and [-].9 and [-]1 to be very strong.

Correspondence of concurrent and retrospective reports

The correspondence of the concurrent and retrospective reports was examined using a Bland-Altman plot. The Bland-Altman plot is a graphical analysis commonly used in medical practice to compare the outcome of two tests measuring the same variable (Bland & Altman, 1986; Zaki, Bulgiba, Ismail, & Ismail., 2012). It depicts a coordinate system with the two measures' joint mean score per measurement on the x-axis, and the difference score of the two measures on the y-axis. In the current study, the x-axis represents the joint mean of the average core affect of the momentary measurements and the recalled core affect. The y-axis represents the per-participant difference score of the average core affect of the momentary measurements minus the recalled core affect.

Predictive value of present state core affect and fluctuation of core affect for recalled core affect

The reported core affect combined with the present state and the fluctuation of core affect were expected to allow a better prediction of the recalled core affect than information of the concurrent measurements only. To investigate this hypothesis, a single linear regression analysis predicting the recalled core affect from the average reported core affect was conducted. This model was compared to the fit of a multiple linear regression analysis predicting the recalled core affect from the average core affect of the momentary measurements, including the last available affect grid, and the standard deviation of core affect. The author hypothesized the multiple linear regression analysis to show an improved model compared to that of the single liner regression analysis, with a positive association between the last available momentary measurement and the recalled core affect, and a negative association between the fluctuation of core affect and the recalled core affect.

Relationship between neuroticism and lower scores in valence.

To evaluate whether the score on the measure of neuroticism is associated with an overestimation of the own unpleasant feelings throughout the past week, a correlational analysis with the score on neuroticism and the difference score of the average valence of the

momentary measurements minus the recalled valence was conducted. If neurotic individuals would overreport the unpleasantness of the feelings of the past week, a negative correlation between the difference score [calculated as "average core affect of the momentary measurements" - "recalled core affect"] and the score on neuroticism would be present. A correlation between 0 and [-].3 was considered to be very weak, a correlation between [-].3 and [-].5 was considered to be moderate, [-].5 and [-].9 to be strong, and [-].9 and [-]1 to be very strong (Cohen, 1992).

Results

Descriptive Statistics

Figure 2 depicts the affect grid with a score that represents the sample's mean scores on both facets, with arousal (M = *13*.22) and valence (M = 36.29) and the respective standard deviations for both valence (red, SD = 22.73) and arousal (blue, SD = 25.77).

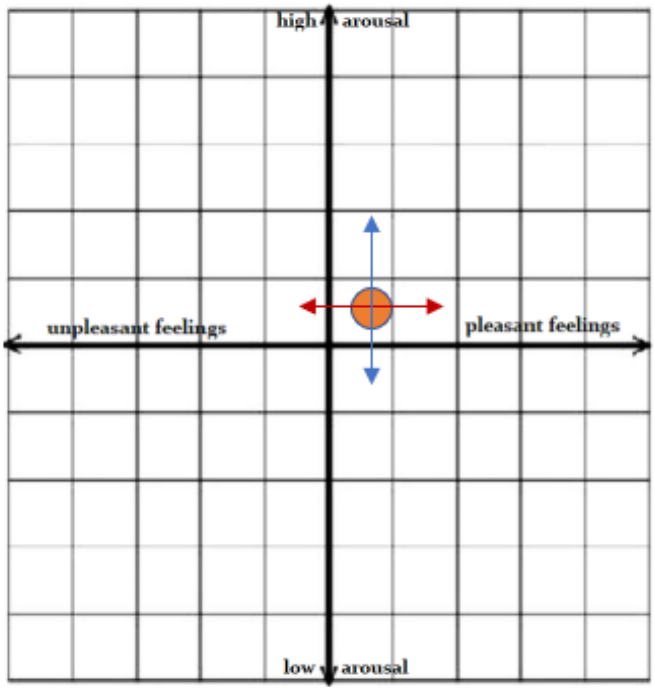

Figure 2. Means and standard deviations for valence and arousal.

The sample's average recalled valence was M = 39.20 (SD = 33.99), and arousal M = 32.12 (SD = 38.58). The mean on the neuroticism scale was M = 31.74 (SD = 8.10) with scores below 36 indicating a low degree of neuroticism. A comprehensive overview of the individual scores can be found in the appendix, see Table 1. Figure 3 shows graphically how the average valence of the momentary measurements, its standard deviation, the recalled valence, and

neuroticism per participant relate. A multiple line graph for arousal is attached in the appendix, see figure 4.

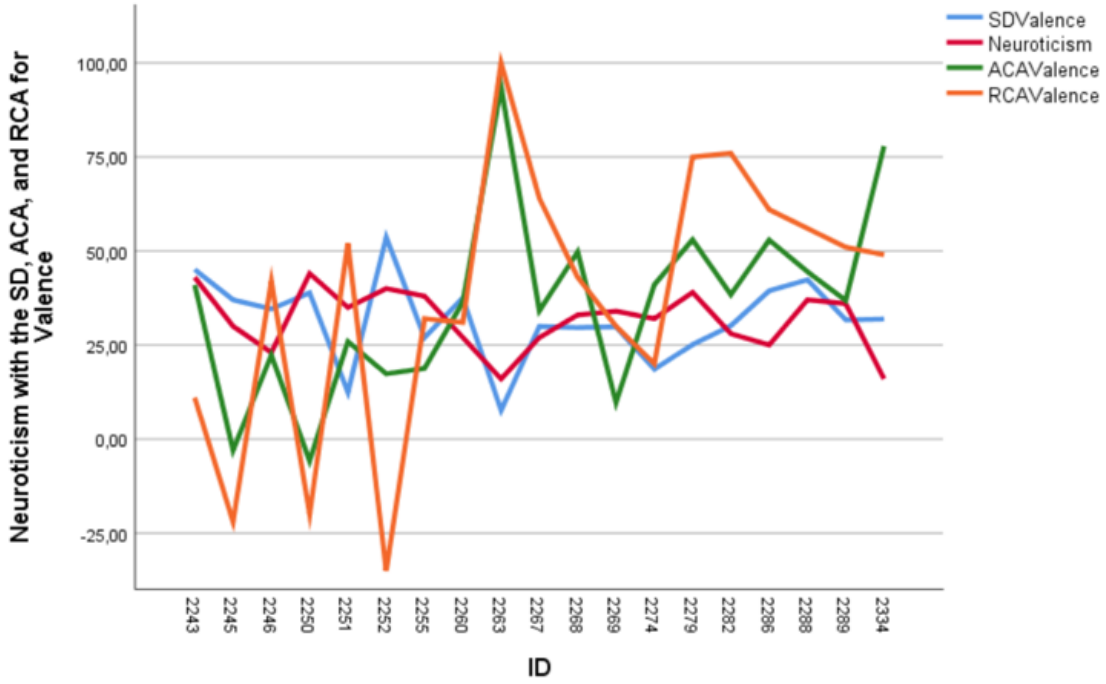

Figure 3. Multiple line graph of participants with neuroticism scores. Per participant the standard deviation, reported and recalled average valence are depicted, including the score on neuroticism.

Relationship between concurrent and retrospective reports

The correlational analysis revealed a significant strong positive relationship between the average arousal as calculated form the momentary measurements and the retrospectively assessed arousal (r=.843 p< .01). This was also the case for valence, with $r=.751$ (N=25) and $p<0.01$.

Correspondence of concurrent and retrospective reports

The Bland-Altman plots are presented in figure 6 and 7. The full blue lines represent the mean of the difference scores of average momentary core affect minus the recalled core affect. The dotted blue lines symbol the confidence interval of the mean, whereas the red lines mark the area that is two standard deviations from the mean. Overall, the mean difference was strongly negative in case of arousal, and close to zero in case of valence. This indicates that participants systematically overestimated their past arousal, whereas they equally over- and underestimated their past valence (Giavarina, 2015). The Bland-Altman plots furthermore supported the impression of a normal distribution of the scores for both valence and arousal, with only few measurements being located beyond two standard deviations.

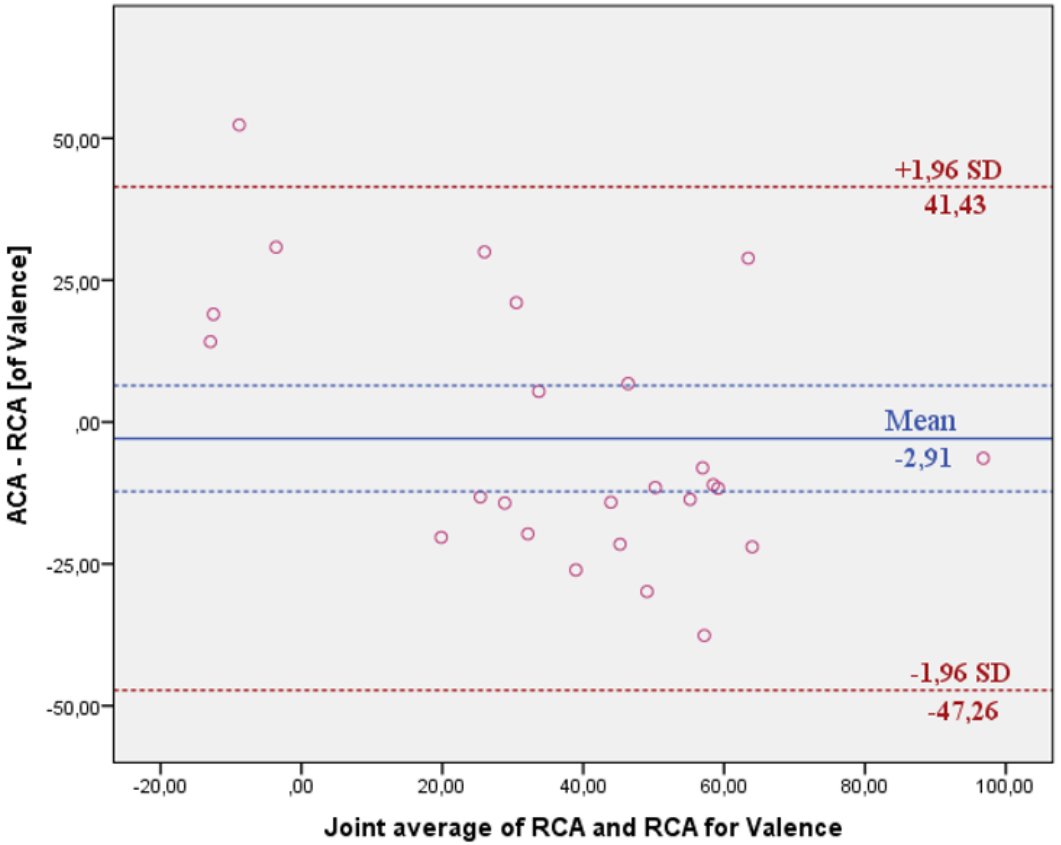

Figure 5. Bland-Altman Plot for valence. The two red lines (the highest and lowest line) mark the distance of two standard deviations from the mean difference score of the ACA and RCA. The blue line in the middle is the mean difference score for the facet valence. The dotted blue lines indicate the 95% confidence interval.

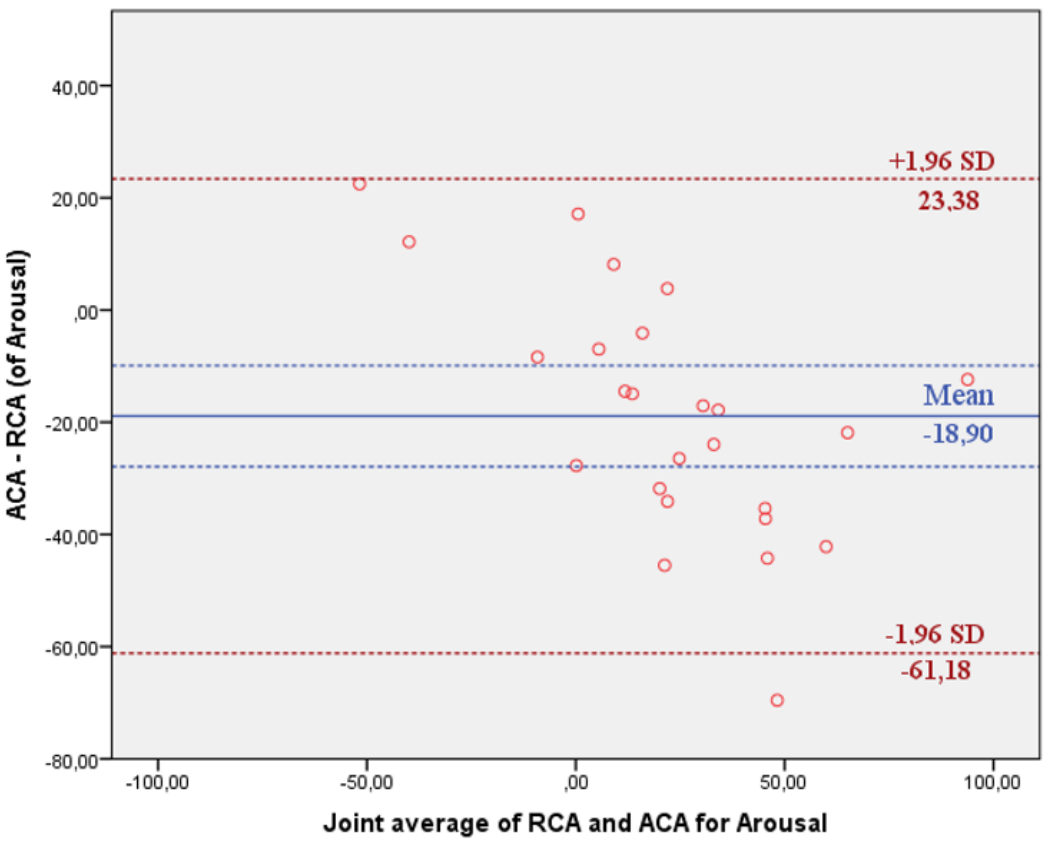

Figure 6. Bland-Altman Plot for arousal. The two red lines (the highest and lowest line) mark the distance of two standard deviations from the mean difference score of the ACA and RCA. The blue line in the middle is the mean difference score for the facet arousal. The dotted blue lines indicate the 95% confidence interval.

Predictive value of present state core affect and fluctuation of core affect for recalled core affect.

First, a linear regression analysis was conducted to examine the prediction of recalled core affect from the reported core affect. A significant model was observed for both arousal ($F(1, 24) = 56.702$, $p < 0.001$) and valence ($F(1, 24) = 29{,}716$, $p < 0.001$) with R^2 of .711 and .564, respectively. In a second step, a linear multiple regression analysis was employed to test the prediction of recalled core affect from the average of the momentary measurements, the last available momentary measurement before the recall, and the within-person standard deviation of core affect (the standard deviation of the average momentary measurements per participant). In both cases the observed model improved, with valence showing a stronger increase ($F(3, 21) = 13.541$, $p < 0.001$, with $R^2_{change} = .095$) than arousal ($F(3, 21) = 18.738$, $p < 0.001$, $R^2_{change} = .017$,). However, when looking at the adjusted R^2, only in case of valence the multiple linear regression model led to an improvement of the model's fit (adjusted $R^2_{change} = .095$), whereas the adjusted R^2 decreased in case of arousal (adjusted $R^2_{change} =$ -.01). Furthermore, the standard deviation of the reported core affect was a significant negative

Table 2
Multiple linear regression results using recalled arousal (RCA) as criterion

Predictor	B	β	SE	*t*	*p*	Fit	Difference
(Intercept)	15.429		4.779	3.228	.004		
ACAArousal	1.263	.843	.168	7.530	.000		
						R^2adjusted = .699 *SEE* = 21.169	
(Intercept)	-.911		15.998	-.057	.955		
ACAArousal	1.262	.843	.203	6.203	.000		
SDArousal	.408	.124	.383	1.065	.299		
LastAGArousal	.041	.052	.104	.392	.699		
						R^2adjusted = .689 *SEE* = 21.508	DIFF R^2adjusted = -.01 DIFF*SEE* = .339

Note: SDArousal refers to the within-person SD during the week of the measurement. The variable LastAGArousal is the last affect grid an individual filled in before the time of the recall and indicates the present state at the time of recall.

predictor only in case of valence (B_1 = -1.208, t = -2.401, p = .026), not however arousal. The last available measurement of core affect was neither in case of valence, nor arousal a significant predictor of the recalled core affect. The coefficients including the adjusted R^2 values are presented in Table 2 and 3.

Table 3
Multiple linear regression results using recalled valence (RCA) as criterion

Predictor	B	β	SE	*t*	*p*	Fit	Difference
(Intercept)	-1,548		8.770	-.177	.861		
ACAValence	1.123	.751	.206	5.451	.000		
						R^2adjusted = .545 *SEE* = 22.935	
(Intercept)	42.705		20.024	2.133	.045		
ACAValence	.896	.599	.238	3.767	.001		
SDValence	-1.208	-.344	.503	-2.401	.026		
LastAGValence	.044	.049	.131	.335	.741		
						R^2adjusted = .611 *SEE* = 21.213	DIFF R^2adjusted = .095 DIFF*SEE* = -1.722

Neuroticism and overreporting of unpleasant feelings.

The correlational analysis with neuroticism and the within-person difference scores on valence turned out to be insignificant (*r=.160,* N=25; *p=.513)*.

Discussion

The goal of this research was twofold: Firstly, to investigate how accurately individuals can recall the core affect that they had experienced in the past week. Secondly, to explore whether factors known to affect the recall of states such as pain and fatigue likewise affect the recall of core affect. With regard to the first goal, the findings indicated that the participants were able to fairly accurately recall the valence they had reported throughout a week. In case of arousal, however, most participants recalled to have experienced stronger arousal than they had reported. With respect to the second research goal, the last momentary measurement before the recall did not predict the recalled core affect. Furthermore, the

fluctuation of arousal throughout the week of the study did not predict recalled arousal. In case of valence, however, stronger fluctuation throughout the measurement period was associated with lower recalled valence. No significant relationship was found between neuroticism and overreporting of past negative states.

Relationship between average momentary and recalled core affect

To begin with, the finding by Broderick et al. (2008) that recalled pain and vitality is only moderately associated with previously reported pain and vitality could not replicated for core affect. Contrary to the hypothesis, the recalled valence and arousal both showed a strong positive relationship with the respective momentary measurements of valence and arousal. This indicates that the participants' retrospective evaluation of the past weeks' core affect was largely based on the core affect that they experienced throughout the week of the study. Based on the finding by Houtveen and Oei (2007) a plausible explanation for the discrepant finding by Broderick et al. (2008) relates to effects of the sample's symptomatology. Houtveen and Oei (2007) reported individuals with stronger symptoms of pain to be more biased when recalling their past experience. This appears to be the case since arousing experiences such as pain tend to capture the own attention and remain salient in the individual's memory (Mather & Sutherland, 2012). The sample population in Broderick et al. (2008) was based on rheumatic individuals and accordingly frequent experiences of pain, whereas in the present study the sample consisted of students without symptom-related inclusion criteria. Accordingly, the absence of arousing pain symptomatology could be a reason why individuals in the present study were able to more accurately recall their past core affect.

Correspondence between average momentary and recalled core affect

With respect to the second hypothesis, the discrepancy between the recalled core affect and the reported core affect was smaller than expected for both, valence and arousal. In case of valence this means that the participants were able to adequately remember how (un-)pleasant they had felt in the past week, without displaying a general tendency to over- or underestimate their past valence. In case of arousal, however, the individuals consistently overestimated how aroused they had felt in the past week. This means that the participants exhibited an overestimation bias in case of arousal, meaning that they tended to generally remember to have experienced stronger arousal throughout the week than they had reported (Giavarina, 2015). The presence of an overestimation bias has likewise been reported in research involving recall of pain symptomatology (Lefebvre & Keefe, 2002; Redelmeier,

Katz, & Kahneman, 2003; Stone et al., 2004; Van den Bergh & Walentynowicz 2016). In support of the notion that recall of arousal and pain could show the same characteristics, Brandon and Daniel (2014) concluded autonomic arousal to be one facet of the pain response. Accordingly, this finding indicates that the recall of arousal is subject to the same characteristics as that of pain, with states of stronger arousal remaining salient in the memory and biasing later recall (Mather & Sutherland, 2012).

Impact of the core affect at the time of the recall on recalled core affect

The last available momentary measurement before the recall did neither predict recalled valence, nor arousal. Accordingly, the core affect that the participants experienced before the recall did not shape their memory of the past week's core affect. This conclusion contrasts with research involving somatic symptoms, that found individuals to remember their past experiences in a way that it is more similar to the present experience than they had reported initially (e.g. Eich et al., 1986; Meek et al., 2001; Safer et al., 2002;). Here is to note that effects of the present state on the outcome of the recall were usually found in relation to considerably higher or lower symptom intensity at the time of the recall (Eich et al., 1986; Houtveen & Oei, 2007; Meek et al., 2001; Safer et al., 2002; Smith & Safer, 1993). The participants in the study by Safer et al. (2002) for instance received information about the outcome of their exam right before being asked to recall their pre-exam anxiety. In the present study the participants were neither exposed to an arousing condition before the recall, nor experienced arousing symptomatology connected to pain. Accordingly, the last available momentary measurement was neither generally higher in arousal, nor contrasted strongly with the participants' mean core affect. In line with conclusions by Mather and Sutherland (2012), this indicates that whereas arousing or contrasting present states such as in Safer et al. (2002) bias the recall, present states that are neither strongly arousing nor stand in stark contrast to the own, general state do not.

Impact of the fluctuation of core affect on the recall of core affect

The finding that the extent of fluctuation of a state such as pain decreases the accuracy with which individuals can recall that state (Kahneman, Fredrickson, Schreiber, & Redelmeier, 1993; Redelmeier & Kahneman, 1996; Schuler et al., 2019) could only be replicated for valence, not however arousal. The present study indicates that individuals who's valence varies stronger over time tend to recall an average state of valence that is more negative than they reported. In other words, the stronger the individuals' valence fluctuated,

the more did they underestimate the pleasantness of their past experience. An explanation for the tendency to underestimate past valence is the relation of the extent of fluctuation of valence to the experience of neutral to negative states of valence. In other words, individual who displayed stronger fluctuations were more likely to experience neutral to negative states of valence, which would bias their later recollection of the week. Several studies reported negative to neutral states of valence to be processed with attention to detail, whereas positive states of valence are not (Bless et al., 1996; Bolte, Goschke, & Kuhl, 2003; Fredrickson & Branigan, 2005; Rowe, Hirsh, & Anderson, 2007). Moreover, Stone et al. (2004) found individuals to base the recall of past pain mainly on those phases during which pain was present, supporting the notion that negative states remain salient in the memory, whereas neutral to positive states are neglected. Conclusively, an explanation for the present relationship is that individuals showing stronger fluctuations of valence recall lower valence than reported because they encountered more neutral to negative states of valence, which remained salient in the memory and biased later recall.

Despite the connection of arousal and pain (Brandon & Daniel, 2014), fluctuation of arousal was not related to the outcome of the recall of arousal. The extent to which the participants' arousal fluctuated did not affect the outcome of the recall, meaning that participants who's arousal changed strongly over time were not less accurate in recalling how aroused they felt throughout the week.

Neuroticism and underestimation of reported valence

Several studies found neurotic individuals to retrospectively overestimate the extent to which they experienced negative affective symptoms and pain (Barrett, 1997; Safer & Keuler, 2002). This finding could not be replicated. In the present study neuroticism was not related to a retrospective underestimation of reported valence. Accordingly, there was no tendency of individuals higher in neuroticism to remember the past week less pleasant than they reported it to have been.

Implications and suggestions for future research.

The initial goal of the current study was to investigate whether individuals are capable to accurately recall how they reported to have felt throughout the past week. This question appeared relevant in light of the reliance of psychodiagnostics on individual recall of affective experience. Despite the finding that the discrepancy in reported and recalled core affect was less than hypothesized, the question remains whether this discrepancy could lead to

"problems in clinical interpretation" (Bland & Altman, 1986, p.308). The average difference between the reported and recalled valence was small (see Figure 5) and is in these cases unlikely to lead to problems in clinical interpretation. However, here is to note that several participants recalled their average core affect to have been much different from what they overall reported, with differences of more than 50 points at times for both, arousal and valence; a discrepancy that equals one fourth of the affect grid's total width. In these cases it appears likely that the conclusions drawn from retrospective self-report questionnaires are different than those based on momentary reports.

Moreover, the recall of arousal was systematically biased towards a retrospective overestimation of the reported arousal. Assuming that individuals would consistently and to a similar extent overestimate how active they felt, issues in medical practice would be unlikely, since this would affect every individual to a similar extent. However, as visible in Figure 6, in the present study some individuals overestimated their arousal to a much stronger extent than others, with few individuals underestimating it. This implies that when interpreting an individual's past experience solely on basis of their retrospective self-report, those individuals who underestimated their past arousal not only seem to have been less active than they actually felt, but even more so when being compared to the majority that tends to overestimate their past arousal. This bears the potential of misinterpreting an individual's past experience based on the retrospective self-report. Since self-report of past activity and energy is part of some diagnostic criteria (e.g. depression), false inferences could in the worst case contribute to diagnostic errors. Understanding which individuals tend to under- rather than overestimate their past arousal therefore could help to prevent misinterpretations in the diagnostic process (DSM-5, 2013).

Another important implication relates to the fluctuation of valence. The present study indicates that individuals who experience stronger fluctuation in valence tend to underestimate their overall valence of the past week. This means that individuals that are asked to report how pleasant they felt in the past week are likely to recall a less pleasant state when they were exposed to stronger changes in mood throughout the week e.g. by reason of repeated phases of distress. Accordingly, when asking individuals to recall how pleasant they felt in the past week(s) it could be valuable to also ask whether the time period was characterized by changes in the mood- even though most likely less reliable than momentary measurements, the response from the individual could indicate when conclusions from the self-report should be drawn more cautiously. However, this is a novel finding and research is required to investigate the assumption that negative to neutral states are the reason for the

impact of the fluctuation of valence on later recall (Bless et al., 1996; Bolte, Goschke, & Kuhl, 2003).

Moreover, future research is needed to investigate whether the absence of arousing symptomatology allows individuals to more accurately recall how they felt. Houtveen and Oei (2007) reported individuals with strong symptoms of pain to exhibit different recall biases than individuals with weak symptoms. Another indication that the effect of arousing symptomatology on later recall is different from that of phases without symptoms comes from Stone et al. (2004), who found individuals to negate periods without pain when retrospectively assessing pain experience. Overall, further research involving the recall of states characterized by everyday arousal and valence could allow to better understand the mechanisms underlying the recall, helping diagnosticians to better understand individual past experience based on retrospective self-report.

Limitations.

The author would like address two potential issues that could have affected the outcome of the analyses. To begin with, the investigation of the present state in this study was based on the last available momentary measurement before the recall. The gap between this measurement and the recall differed between the participants. Had the participant filled in every affect grid right away, the time difference would have been one night- the last momentary measurement took place at 8pm, the request to recall at 10am the next morning. However, this gap was larger the later the participant responded to the request to recall, and the farther in the past the last available momentary measurement lay. Accordingly, the more time passed between the last momentary affect grid and the recall, the less representative would the last momentary measurement be for the state an individual experienced at the time of the recall. As the saliency of past experience decreases with time, this could have played a role in the nonsignificant association between the last momentary measurement and the recalled core affect (Broderick et al., 2008; Feine, Lavigne, Thuan Dao, Morin, & Lund, 1998). Another potentially confounding factor is the possibility the participants were not aware of the instruction to retrospectively assess their average core affect- this is a rather generic issue, however, considering the set-up of this study it should be mentioned; To keep the recall spontaneous the participants received information about the instruction to recall their average core affect shortly before the 43rd affect grid appeared on screen, and a second time with the appearance of the affect grid. Had they neither read the notification nor the

instruction, they would have interpreted the 43rd measurement as another momentary measurement. The author has no indication that this indeed was an issue. However, to eliminate the possibility of misunderstandings, future research could include a final question item in which the participants are asked whether they were aware of the instruction to retrospectively assess their experience.

Conclusion

The present study found a strong relationship between momentary and retrospective measurements, with adequate correspondence between the recalled and the reported core affect. However, individuals systematically overestimated their reported arousal. Furthermore, the fluctuation of valence was related to an underestimation of reported valence. . Findings on the influence of the present state, the fluctuation of arousal, and neuroticism were not associated with recalled core affect and indicate that different factors affect the recall of core affect compared to strong arousing experiences such as pain.

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Appendix A

Per-participant mean scores

Table 1

Individual scores for ACA, RCA, the last momentary measurement, and neuroticism.

ID	ACA Valence	ACA Arousal	RCA Valence	RCA Arousal	Last momentary measurement arousal	Last momentary measurement valence	Neuroticism
2243	40,98	11,54	11,00	38,00	-48,00	82,00	43,00
2245	-3,01	9,12	-22,00	-8,00	-22,00	-23,00	30,00
2246	22,30	38,82	42,00	81,00	86,00	47,00	23,00
2250	-5,85	-13,39	-20,00	-5,00	52,00	59,00	44,00
2251	25,93	25,17	52,00	43,00	31,00	36,00	35,00
2252	17,35	-1,49	-35,00	44,00	50,00	48,00	40,00
2255	18,79	2,03	32,00	9,00	-13,00	-10,00	38,00
2260	36,40	-13,74	31,00	14,00	-21,00	27,00	27,00
2262	52,94	-33,85	64,00	-46,00	20,00	57,00	-
2263	93,62	87,61	100,00	100,00	100,00	99,00	16,00
2267	34,12	6,07	64,00	21,00	-31,00	17,00	27,00
2268	49,77	21,05	43,00	45,00	-70,00	-1,00	33,00
2269	9,69	13,88	30,00	18,00	36,00	14,00	34,00
2274	41,03	23,83	20,00	20,00	32,00	36,00	32,00
2279	53,00	54,14	75,00	76,00	53,00	32,00	39,00
2282	38,38	13,44	76,00	83,00	2,00	34,00	28,00
2286	52,91	27,62	61,00	63,00	77,00	68,00	25,00
2288	44,47	4,88	56,00	39,00	-43,00	66,00	37,00
2289	36,86	4,17	51,00	36,00	7,00	70,00	36,00
2294	21,73	21,92	36,00	39,00	-46,00	1,00	-
2310	53,33	23,76	65,00	68,00	64,00	-54,00	-
2311	34,46	26,80	56,00	64,00	79,00	67,00	-
2312	11,81	13,13	-19,00	5,00	43,00	-30,00	-
2317	48,37	-40,53	62,00	-63,00	-65,00	66,00	-
2334	77,87	4,51	49,00	19,00	24,00	70,00	16,00

Note. Individuals who do not have a score on neuroticism could not be included in the analysis due to technical issues that made their answers to the neuroticism scale inaccessible.

Multiple line graph of arousal

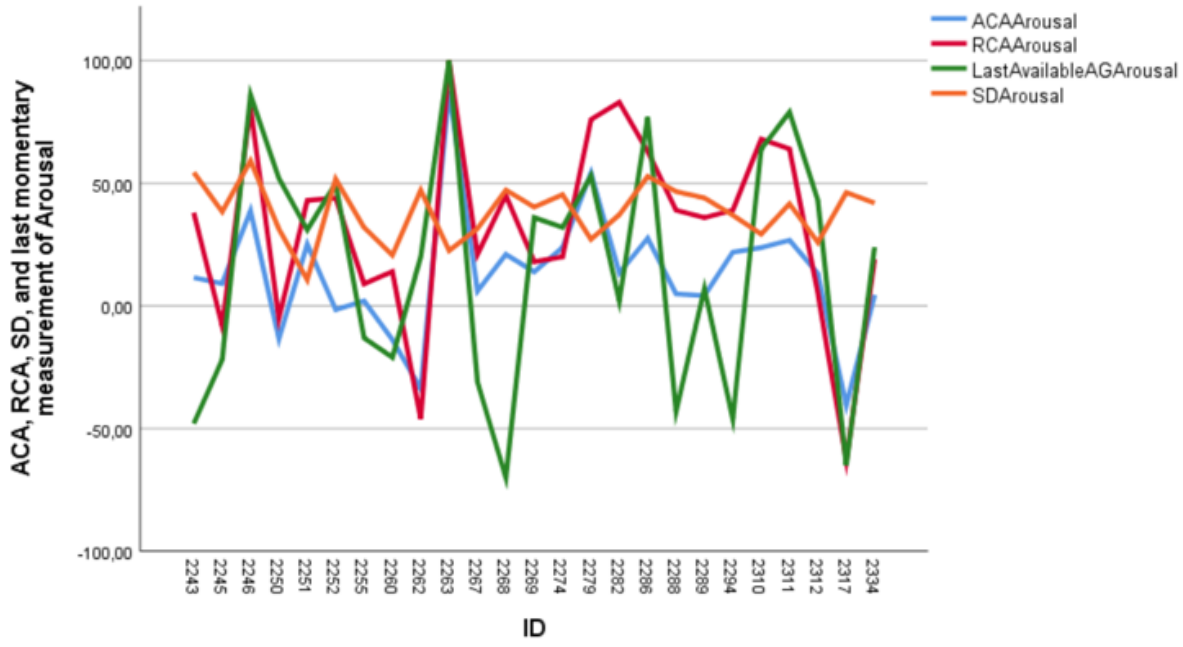

Figure 4. Multiple line graph of arousal. Per participant the standard deviation, reported and recalled average valence are depicted, as well as the last available momentary measurement, representing the present state.

Appendix B

Participant instructions prior to the study

Hey [account name]!
Thank you for taking part in our study.
In the following, we will provide a short outline on the set-up and the theoretical background of this study.
In general, this study serves the investigation of changes in core affect over time.

Core affect represents what is commonly called mood or feelings, and consists of two dimensions- valence and arousal.
Valence represents how **pleasant** you feel at the moment and ranges from **unpleasant** to **pleasant**.
Arousal represents how **activated** you feel at the moment and ranges from **sleepy** to **activated**.

These two dimensions are represented in the **Affect Grid**, the test you will fill in repeatedly in the course of this study.
The Affect Grid is a coordinate system with *valence represented on the x-axis* (horizontal)

and *arousal on the y-axis* (vertical).
You can refer to the point where both axes cross as *'neutral state of feelings'*.
By setting a mark somewhere in this coordinate system you indicate how you feel-
both pleasant/unpleasant and sleepy/activated in one mark!
(this means, that if you feel very active and pleasant you set a mark far to the right upper corner,
if you feel pleasant but rather sleepy/inactive you set it far to the right but in the lower corner)

(please read the information above carefully- understanding this is necessary to successfully fill in the affect grid!)
(you can also make a screenshot of this description in case you want to read it at a later point again)

Your task is *to set a mark in the coordinate system every two hours between 10:00 and 20:00 o'clock* (six times per day) for 7 days.
You do not have to keep track of the time yourself, the app will send you a notification every two hours within this time frame to fill in the Affect Grid.
(therefore please allow the app to send you notifications!)
If you are not able to fill in the grid right away, you can do so a few minutes later, but please try to do so in time.
We hope that you can answer as many times as possible!

To start the study, please download the app TiiM - The incredible intervention machine and log in with the credentials you chose.
You will start by answering three questionnaires and then the study will begin-
We hope you are as excited about this study as we are!

Best,
[researchers]
PS: In case of any open questions, issues, or critique please do not hesitate to contact

[Names and corresponding mail addresses of the researchers]

Items of the Eysenck-Neuroticism-Scale EPQ-S (Eysenck et al., 1985).

1. Does your mood often go up and down?
2. Do you ever feel ‘just miserable’ for no reason?
3. Are you an irritable person?
4. Are your feelings easily hurt?
5. Do you often feel ‘fed-up’?
6. Would you call yourself a nervous person?
7. Are you a worrier?
8. Would you call yourself tense or ‘highly strung’?
9. Do you worry too long after an embarrassing experience?
10. Do you suffer from ‘nerves’?
11. Do you often feel lonely?
12. Are you often troubled about feelings of guilt?

Acknowledgements

The author thanks Julia Müller for granting him access to the data gathered on neuroticism.