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The measurement of core affect: A Swedish self-report measure derived from the affect circumplex

DANIEL VÄSTFJÄLL[1,2], MARGARETA FRIMAN[3], TOMMY GÄRLING[1] and MENDEL KLEINER[2]

[1]*Department of Psychology, Göteborg University, Sweden*
[2]*Department of Applied Acoustics, Chalmers University of Technology, Sweden*
[3]*The Service Research Center, Karlstad University, Sweden*

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Three studies were conducted with the aim of developing a new Swedish self-report measure of core affect (the Swedish Core Affect Scale or SCAS). In Study 1,122 participants rated their current mood on 24 unipolar adjective scales. A revised set of 12 bipolar adjective scales was evaluated in Study 2 employing 96 participants who rated their current mood before and after a mood-inducing naturally occurring event. A slightly revised set of adjective scales was used in Study 3, in which another 96 participants rated several induced moods. The results showed that the adjective scale ratings could be aggregated as reliable measures of the independent valence and activation dimensions proposed in the affect circumplex, and that the aggregated measures discriminated mood differences within and between individuals.

Key words: Emotion, core affect, self-report measure, adjective-scale ratings.

Daniel Västfjäll, or Tommy Gärling, Department of Psychology, Göteborg University, Box 500, SE-40530 Göteborg, Sweden. E-mail: Daniel.Vastfjall@psy.gu.se or Tommy.Garling@psy.gu.se

INTRODUCTION

A consensus seems to be slowly emerging about how to define concepts like emotion, mood, affect, feeling, and temperament (Averill, 1975; Frijda, 1993; Lewis & Haiveland, 1993; Watson & Clark, 1994b; Zajonc, 1997). Clarification is, however, still necessary at both theoretical and empirical levels. An important step in this direction was taken by Russell and Feldman Barrett (1999) when they introduced two interrelated key concepts for understanding any affective process, core affects, and prototypical emotional episodes.

A prototypical emotional episode is an experienced or anticipated chain of events (e.g., Lazarus, 1991) consisting of antecedents, appraisals, physiological, affective, and cognitive changes, and behavioral responses. Prototypical emotional episodes constitute a finite discrete set that can be enumerated and described. Examples include surprise, disappointment, anger, disgust, fear, and happiness (Ekman, 1993).

Core affects are cognitively accessible elements of a current mood, an emotional reaction, or an anticipated emotional reaction. They are present at any given time, even at a neutral level. Numerous studies have been performed to investigate the structure of core affects.

It was suggested early that core affects can be described by a set of underlying dimensions. For instance, Wundt (1924) concluded from introspection of affective reactions to auditory rhythms that three dimensions may account for all possible differences between affective states: pleasure–displeasure, strain–relaxation, and excitement–calmness. Later, Schlosberg (1952, 1954) proposed an additional dimension, corresponding to sleep–tension. However, more recent evidence from judgments of similarity between emotion adjectives (Block, 1957; Bush, 1973; Russell, 1978, 1979; Reisenzein, 1994), judgments of facially expressed emotions (Russell & Bullock, 1985), self-reported mood (Feldman, 1995a, 1995b; Feldman Barrett, 1996; Mayer & Gaschke, 1988; Meyer & Schack, 1989; Morgan & Heise, 1988; Russell & Steiger, 1982; Watson, Clark & Tellegen, 1984), and psychophysiological measurements (Cacioppo, Gardner & Berntson, 1999; Lang, 1995; Lang, Bradley & Cuthbert, 1990; Lang, Greenwald, Bradley & Hamm, 1993) suggests that two dimensions are sufficient.

In two-dimensional models, core affects are organized in a circular or circumplex structure (Russell, 1980). Four such models have been proposed (Carroll, Yik, Russell & Feldman Barrett, 1999; Yik, Russell & Feldman Barrett, 1999): Russell's affect circumplex (Russell, 1980; see also Feldman Barrett & Russell, 1998, for a revised model); Watson and Tellegen's (1985) positive–negative affect circumplex; Larsen and Diener's (1992) eight octant circumplex; and Thayer's (1987) tense and energetic activation dimensions. Larsen and Diener (1992) (see also Browne, 1992; Fabrigar, Visser & Browne, 1997) noted that circumplex models imply: (1) that affects vary in their degree of similarity to one another with respect to two underlying dimensions; and (2) that affects are more or less evenly spaced around the circumference of the circumplex rather than being grouped together in clusters.

Russell (1980) suggested that the two main affect dimensions or axes reflect degrees of pleasantness–unpleasantness and arousal. In support of this suggestion, participants tended

to arrange eight affect categories (excitement, pleasure, contentment, sleepiness, depression, misery, distress, and arousal) in a circular pattern, with axes corresponding to pleasure–misery and aroused–sleepy at right angles to each other and secondary axes at 45 degrees, corresponding to excitement–depression and contentment–distress. In addition, factor analysis of self-report ratings of mood on adjective scales have revealed a pleasure–displeasure and an arousal dimension. In the most recent version of the affect circumplex (Russell & Feldman Barrett, 1999), the dimensions are labeled valence and activation.

In an alternative circumplex model, Watson and Tellegen (1985) labeled the two dimensions positive affect (PA) and negative affect (NA). PA reflects pleasurable engagement with the environment and is characterized by affects such as euphoric, peppy, and elated, implying a combination of valence and activation. NA includes distressing and unpleasant affective states such as anxiety and anger, suggesting high activation and high unpleasantness. The PANAS mood scales (Watson, Clark & Tellegen, 1988) were derived from Watson and Tellegen's (1985) circumplex model. The model can, however, be criticized on several grounds (Larsen & Diener, 1992). "Positive affect" and "negative affect" are misleading labels because low values of positive affect are experienced as unpleasant states and low values of negative affect as pleasant. Later Watson and Clark (1994a) extended the original PANAS scales to cover the full circumplex, with both high and low values on the two dimensions. They also renamed the dimensions as negative and positive activation (Watson, Wiese, Vaidya & Tellegen, 1999; Watson & Tellegen, 1999). A suggestion is therefore that the PA/NA dimensions are rotated 45 degrees relative to the valence and activation axes (Russell & Feldman Barrett, 1999).

Two additional models are Thayer's (1986) energetic-tensed arousal dimensions and Larsen and Diener's (1992) eight octant circumplex. In contrast to Russell (1980), Thayer (1986, 1989) concluded that two dimensions are needed to account for the activation dimension, energetic arousal and tense arousal. High markers of the energetic dimension include energetic, carefree, and elated, while low markers include tired and sluggish. High markers of the tense dimension are tense, intense, and anxious, while low markers are still and calm. It thus seems as if the energetic dimension largely corresponds to the PA dimension, and the tense arousal dimension to the NA dimension of Watson and Tellegen (1985). In fact, research focussing on only one dimension, either valence (Lykken & Tellegen, 1996; Watson & Tellegen, 1985) or activation (Thayer, 1986), does not find a single dimension of affect but rather the combination of the two fundamental dimensions of activation and valence (Yik *et al.*, 1999). Furthermore, the framing of dimensions as either valence (positive or negative affect) or activation (tense and energetic arousal) seems arbitrary in that the dimensions overlap, and in that they reflect combinations of valence and activation.

The four proposed models of affect structure (Larsen & Diener, 1992; Russell, 1980; Thayer, 1986; 1989; Watson & Tellegen, 1985) thus appear to be interchangeable. Indeed, several researchers assume that the models are rotational variants (Burke, Brief, George, Robertson & Webster, 1989; Lang, 1995; Mano, 1992). In support of this, a recent study (Yik *et al.*, 1999) found a substantial empirical overlap between the four models.

In summary, *valence* and *activation* appear to be necessary and sufficient to describe the structure of core affects. As shown in Figure 1, the intermediate dimensions of positive affect, energetic arousal, or activated pleasant affect-deactivated unpleasant affect will be referred to as *pleasant activation–unpleasant deactivation*, whereas the intermediate negative affect, tense arousal, or activated unpleasant affect–deactivated pleasant affect will be referred to as *unpleasant activation–pleasant deactivation*. The valence dimension is interpreted as reflecting the degree of affect that provides information about current well-being (Russell & Feldman Barrett, 1999). It is clearly a fundamental dimension of human experience. Many others have used other concepts to refer to the same thing: pleasure–displeasure, good–bad mood, pleasure–pain, approach–avoidance, positive–negative, or hedonic tone (Kahneman, Diener & Schwarz, 1999; Russell & Feldman Barrett, 1999). Much of the research on the effects of mood and affect has furthermore targeted this single dimension (Isen, 1993). Yet it has not been denied that at least one additional dimension is needed. The second dimension, activation, refers to the subjective experience of energy or mobilization (Russell & Feldman Barrett, 1999). Activation ranges from deactivation (still, quiet) over a neutral state to high activation (activated, aroused). The activation dimension is also referred to as arousal, energy, activity, or tension (Thayer, 1989).

A Swedish mood scale was developed by Sjöberg, Svensson and Persson (1979)[1]. Three factors from exploratory factor analysis were labeled social orientation, social orientation motive, and control. They were not assumed to be intrinsic to the affective experience (Svensson, 1978). Another three factors were more clearly related to the affect circumplex (Russell, 1980; Russell & Feldman Barrett, 1999). First,

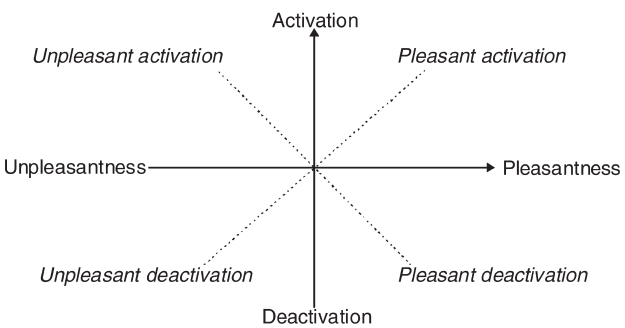

Fig. 1. The circumplex model of affect. (Adapted from Russell, 1980.)

the bipolar pleasantness factor appears to be equivalent to valence. Markers were adjectives such as happy, sad, satisfied, dissatisfied, pleasant, and unpleasant. Despite labeled activation, the second factor does not, however, seem to correspond to activation. It corresponds more closely to positive activation/affect (Watson *et al.*, 1999), energetic arousal (Thayer, 1989), or pleasant activation–unpleasant deactivation (Larsen & Diener, 1992), with markers such as interested, concentrated, energetic, tired, and listless. Yet, pure activation markers such as passive–active and aroused–quiet also define this dimension, indicating that it is related to activation. The third factor, tension, largely corresponds to negative affect/activation (Watson *et al.*, 1999), energetic arousal (Thayer, 1989), or unpleasant activation–pleasant deactivation (Larsen & Diener, 1992), with markers such as tense, cold, angry, helpful, and accommodating. Thus, it may be concluded that the mood adjective scales derived by Sjöberg *et al.* tap valence. However, they do not seem to tap activation but the two independent dimensions of valenced activation.

Bohlin and Kjellberg (1973) and Kjellberg and Bohlin (1974) developed an inventory consisting of Swedish adjectives describing arousal or activation. Exploratory factor analysis resulted in six factors, which were interpreted as bipolar sleep–wakefulness, bipolar stress, unipolar euphoria, bipolar energy, unipolar attention, and unipolar irritation. The sleep–wakefulness and energy factors were conceived of as positively valenced high-activation dimensions believed to reflect a subjective interpretation of the bodily state. It thus coincides with the high markers of energetic arousal (Thayer, 1986), positive affect/activation (Watson *et al.*, 1999), and pleasant activation (Larsen & Diener, 1992). The euphoria and concentration factors were also considered to reflect positively valenced high activation. These factors may alternatively cover energetic arousal (Thayer, 1986), positive affect/activation (Watson *et al.*, 1999), and pleasant activation (Larsen & Diener, 1992) since they have bipolar counterparts of negatively valenced low-activation markers. In addition, Bohlin and Kjellberg (1973) and Kjellberg and Bohlin (1974) argued that concentration reflects the influence of situational factors (e.g., concentration on an object or task), whereas the euphoria factor does not. They also argued that the negatively valenced high activation–positively valenced low activation factor reflects an appraisal of the situation or object whereas the irritation factor does not. The stress and irritation factors correspond to tense arousal (Thayer, 1986), negative affect/activation (Watson *et al.*, 1999), and unpleasant activation–pleasant deactivation (Larsen & Diener, 1992). Thus, it seems as if the scales developed by Bohlin and Kjellberg (1973) and Kjellberg and Bohlin (1974) do not provide direct measures of valence and activation.

To conclude, the currently available Swedish rating-scale measures of affect (Bohlin & Kjellberg, 1973; Kjellberg & Bohlin, 1974; Sjöberg *et al.*, 1979, Svensson, 1977, 1978) do not appear to directly tap the independent dimensions of valence and activation of the affect circumplex (Russell, 1980; Russell & Feldman Barrett, 1999). Therefore, there is a need to refine these measures to take into account the recent theoretical and empirical developments in research on core affects.

The aim of the present research is to develop a new Swedish measure of core affects (the Swedish Core Affect Scale, or SCAS) that directly taps valence and activation, and which also makes it possible to obtain measures of pleasant activation–unpleasant deactivation and unpleasant activation–pleasant deactivation. In Study 1 mood ratings on unipolar adjective scales compiled from previous research were subject to multidimensional scaling, exploratory factor analysis, and confirmatory factor analysis. These analyses resulted in a revised set of bipolar adjective scales that were further evaluated in Studies 2 and 3.

STUDY 1

Method

Participants. One hundred twenty-two undergraduates at Chalmers University of Technology, Göteborg, Sweden (70 men and 52 women) participated on a voluntary basis. Their mean age was 24.4 years (*SD* 6.1, range 18–61 years).

Adjective scales. Twenty-four unipolar adjectives were selected on the basis of the results of the two previous Swedish studies conducted by Bohlin and Kjellberg (1973) and Sjöberg *et al.* (1979). The aim was to select three adjectives from each endpoint of the hypothesized dimensions of valence (pleasantness–unpleasantness), pleasant activation–unpleasant deactivation, activation (arousal), and unpleasant activation–pleasant deactivation. Some changes of the selected adjectives were subsequently made on the basis of the results of pilot studies. The following adjectives were retained (translated from the Swedish adjectives given in parentheses): peppy (*pigg*), energetic (*energisk*), active (*aktiv*), dull (*slö*), quiet (*dämpad*), and passive (*passiv*) (**activation**); pleased (*belåten*), glad (*glad*), harmonious (*harmonisk*), depressed (*nedslagen*), in a bad mood (*illa till mods*), and sad (*ledsen*) (**valence**); optimistic (*optimistisk*), in a good mood (*på gott humör*), enthusiastic (*entusiastisk*), tired (*trött*), faint (*matt*), and bored (*uttråkad*) (**pleasant activation–unpleasant deactivation**); and calm (*lugn*), relaxed (*avslappnad*), serene (*avspänd*), nervous (*nervös*), tense (*spänd*), and stressed (*jäktad*) (**unpleasant activation–pleasant deactivation**). The translated adjectives correspond closely to those used by Feldman Barrett and Russell (1998).

Procedure. Participants took part either individually (n = 40) or in groups (n = 82). The former participants made the adjective scale ratings first in a series of tasks performed in a laboratory setting. Participants in groups were requested to make the ratings before or after a lecture. Ten to 30 participants took part on four different occasions at different times of the day.

The same procedure was used for both individual and group participants. After a brief oral introduction, the experimenter administered the adjective scales. The participants were asked to indicate the degree to which the adjectives described how they felt at that particular moment. The adjectives were printed on a single page. Four different orders were used for different participants. On the

row below each adjective, a scale was printed with endpoints and a middle point defined by the numbers 10 (not at all), 50 (average), and 90 (extremely much), written in boxes from left to right. In between there were two open boxes. Participants could either write an appropriate number in these (11 to 49, or 51 to 89) or cross one of the filled boxes. The participants needed about five minutes to check the scales. They were debriefed and thanked for their participation when finished.

Results and discussion

The adjective ratings were first submitted to principal component analysis. This yielded five factors with eigen values larger than 1.0 accounting for 79.6% of the variance. Only two factors were varimax rotated since the scree criterion suggested that this number would provide an acceptable fit. The two-factor structure accounted for 52.1% of the variance. As may be seen in Table 1, which shows the factor loadings, factor 1 corresponds to valence and factor 2 to activation.

Metric multidimensional scaling (ALSCAL; see Davidson, 1985; Young, Takane & Lewyckyj, 1978) was also applied. A two-dimensional solution was obtained for a R^2 of 0.78. As can be seen in Figure 2, the adjective scales appear to closely concord with a circumplex structure. A statistical test was performed with the CIRCUM procedure, which is a covariance structural modeling method (Browne, 1992; Remington, Fabrigar & Visser, 2000). First, eight variables were constructed by averaging the ratings on the three adjectives for each endpoint of activation, valence, pleasant activation–unpleasant deactivation, and unpleasant activation–pleasant deactivation, respectively. The polar angles of vectors corresponding to the eight octants within the circumplex were calculated from the scale intercorrelations. With the high-activation vector chosen as reference (0 degrees), the vectors corresponding to the remaining octants are expected to have the following angles relative to the reference vector (measured clockwise) (Russell, 1980): Pleasant activation 45 degrees, high valence 90 degrees, pleasant deactivation 135 degrees, low activation 180 degrees, unpleasant deactivation 225 degrees, low valence 270 degrees, and unpleasant activation 315 degrees. The procedure assesses if the octants are ordered as predicted along the circumference of a hypothesized circle, thus making it possible to assess the goodness of fit of a circumplex model (Fabrigar *et al.*, 1997). As Figure 3 shows, the adjective ratings show acceptable agreement with the predicted angles. This was supported by a nonsignificant χ^2(d.f. = 7, n = 122) = 9.89, $p > 0.05$, and additional fit statistics (RMSEA = 0.07, AGFI = 0.89, and CFI = 0.92) that were satisfactory (Browne & Cudeck, 1993; Fabrigar *et al.*, 1997). Thus, the results indicated that the adjective ratings reflect a circumplex structure of core affects.

In summary, the results support the conclusion that the adjective ratings tap the hypothesized dimensions of activation, valence, pleasant deactivation–unpleasant activation, and pleasant activation–unpleasant deactivation. Four bipolar indices corresponding to each of these dimensions were therefore constructed by summing across the six rating scales assumed to measure each dimension. Table 2 reports Cronbach's α for each index as well as their intercorrelations. As may be seen, the affect indexes have acceptable

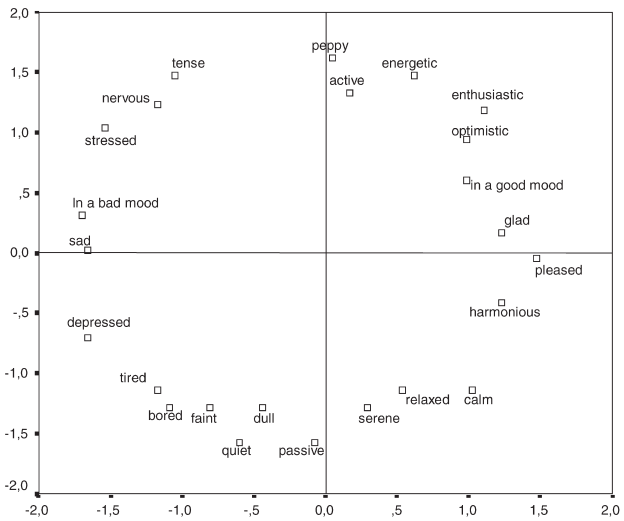

Fig. 2. Plots of two-dimensional solutions from the multidimensional scaling of unipolar adjective scale ratings (Study 1).

Table 1. *Varimax rotated loadings from principal component analysis of adjective ratings (Study 1)*

Adjective	*M*	*SD*	Factor 1	Factor 2	h^2
Peppy	51.56	18.88	0.03	**0.90**	0.81
Energetic	22.53	14.86	0.40	**0.51**	0.42
Active	39.80	19.37	0.08	**0.90**	0.81
Dull	54.25	19.69	−0.06	**−0.92**	0.84
Quiet	28.73	18.13	−0.13	**−0.71**	0.51
Passive	38.05	20.46	−0.12	**−0.82**	0.67
Pleased	33.66	21.04	**0.90**	0.00	0.81
Glad	48.12	21.44	**0.88**	0.06	0.78
Harmonious	38.95	20.54	**0.54**	−0.22	0.30
Depressed	45.28	18.75	**−0.83**	−0.14	0.69
In a bad mood	50.91	20.98	**−0.66**	0.29	0.44
Sad	48.08	19.78	**−0.81**	−0.15	0.65
Optimistic	58.15	21.49	0.49	0.42	0.42
In a good mood	43.70	22.66	0.72	0.31	0.53
Enthusiastic	52.89	20.88	0.44	0.42	0.35
Tired	27.16	19.13	0.12	−0.50	0.26
Faint	50.42	19.96	−0.11	−0.59	0.36
Bored	56.43	18.83	−0.67	0.18	0.48
Calm	35.60	19.66	0.52	−0.39	0.42
Relaxed	39.23	21.03	0.59	−0.33	0.45
Serene	49.70	21.15	0.51	−0.12	0.27
Nervous	32.77	18.22	−0.52	0.43	0.45
Tense	54.09	19.74	−0.49	0.23	0.29
Stressed	37.70	22.53	−0.67	0.21	0.49
Variance (%)			29.6	22.5	52.1

Note: Values in bold denote loadings for hypothesized valence (factor 1) and activation (factor 2) items.

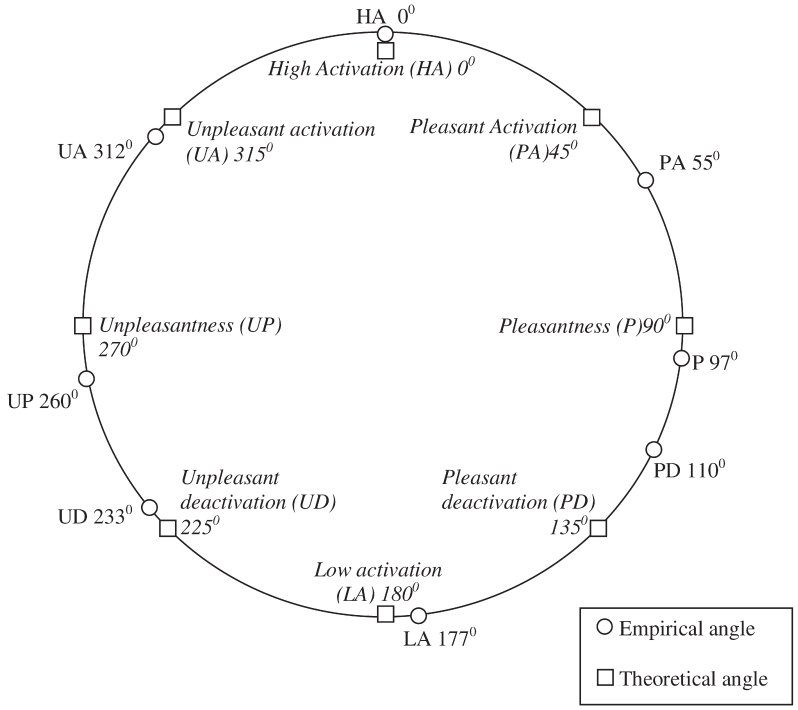

Fig. 3. Angles between vectors corresponding to octants in the affect circumplex calculated from unipolar adjective scale ratings (Study 1).

Table 2. *Means, standard deviations, intercorrelations, and Cronbach's* α*s for affect indices (Study 1)*

	M	*SD*	A	V	UAPD	PAUD
Activation (A)	18.5	12.7	0.90			
Valence (V)	29.2	10.0	0.12	0.92		
Unpleasant activation–pleasant deactivation (UAPD)	−17.2	11.7	0.35	−0.39	0.93	
Pleasant activation–Unpleasant deactivation (PAUD)	23.9	10.1	0.78	0.57	−0.08	0.87

Note: Cronbach's αs are given in the main diagonal.

reliability (Cronbach's alphas ranging from 0.87 to 0.93). The intercorrelations furthermore show the expected pattern.

STUDY 2

Although the adjective scales used in Study 1 may be used for any application, it would be desirable to develop a shorter version with comparable psychometric properties. Since it is now clearly recognized that the affect dimensions are bipolar (Bentler, 1969; Bradburn, 1969; Green, Goldman & Salovey, 1993; Green & Salovey, 1999; Green, Salovey & Truax, 1999; Russell, 1979; Russell & Carroll, 1999a, 1999b; Watson, 1988; Watson & Clark, 1997; Watson & Tellegen, 1999), the unipolar adjective scales used in Study 1 were reduced to 12 bipolar scales. Another sample of participants was recruited to allow additional dimensional analyses. The mood measurements were furthermore obtained twice, before and after an event (a lecture). Previous research has suggested that sustained attention over a period of time may lead to decreases in both valence and activation (Thayer, 1987). We therefore wanted to know if the measure would be sensitive enough to detect such changes.

Method

Participants. Ninety-six undergraduates (42 male and 54 female) at Göteborg and Karlstad Universities participated on a voluntary basis. Their mean age was 25.2 years (*SD* 3.1, range 19–56 years).

Adjective scales. Twelve bipolar adjective scales were constructed from the unipolar scales used in Study 1. Adjective pairs with high negative correlations were first selected. When it was impossible to find a pair of antonyms, an adjective with high loading was retained and another more appropriate antonym was selected from the adjectives used in the previous Swedish studies (Bohlin & Kjellberg, 1973; Kjellberg & Bohlin, 1974; Sjöberg *et al*., 1979). In a few cases a new adjective had to be selected as antonym. There were three bipolar

adjective scales for each of the dimensions (the Swedish adjective pairs are given in parentheses): dull–peppy (*slö–pigg*), sleepy–awake (*sömnig–vaken*), and quiet–energetic (*dämpad–energisk*) (**activation**); displeased–pleased (*missnöjd–belåten*), sad–glad (*ledsen–glad*), and depressed–happy (*nedslagen–munter*) (**valence**); bored–interested (*uttråkad–intresserad*), indifferent–engaged (*oengagerad–engagerad*), and pessimistic–optimistic (*pessimistisk–optimistisk*) (**pleasant activation–unpleasant deactivation**); and tense–serene (*spänd–avspänd*), anxious–calm (*orolig–lugn*), and nervous–relaxed (*nervös–avslappnad*) (**unpleasant activation–pleasant activation**).

Procedure. Participants recruited in classes were requested to perform ratings of their current mood before and after a lecture. The data were collected on six different occasions at different times of the day, with between 10 and 20 participants each time. After a brief oral introduction, the experimenter administered the adjective scales typed on a single page. The participants were asked to indicate the degree to which the adjectives described how they felt at that particular moment. Except for changing the scales to bipolar, the response format was the same as in Study 1. Thus, participants could respond with any number from 10 (extremely [left-end adjective]) to 90 (extremely [right-end adjective]) through 50 (neutral). Likewise, four different orders of the scales were administered. The participants needed about five minutes to check the scales. They were then informed that the experimenter would return at the end of the lecture with some additional questions. When the experimenter returned, the participants were once again asked to check the adjective scales. Participants were finally debriefed and thanked for their participation.

Results and discussion

To test the hypothesized two-dimensional circumplex structure, the correlation matrices were submitted to principal axis factor analyses. For the time-1 and time-2 ratings, two-dimensional solutions accounted for 57.7% and 65.9% of the variance, respectively. As can be seen in Table 3, the adjectives load as predicted on the two factors. For the time-1 ratings, adjective pairs denoting valence and activated valence have high loadings on the first factor, and activation and valenced activation adjective pairs have high loadings on the second factor. For the time-2 ratings, adjective pairs denoting activation and valenced activation load on the first factor, and valence and activated valence adjectives load on the second factor, thus largely also supporting the hypothesized two-dimensional structure. However, closer inspection of simple correlations between the adjective scales revealed that the activation adjective pair quiet–energetic correlated poorly with the other activation adjectives.

As in Study 1, four bipolar indices corresponding to each of the dimensions activation, valence, pleasant activation–unpleasant deactivation, and unpleasant activation–pleasant deactivation were constructed by summing across the three adjective scales assumed to measure each dimension. Table 4 reports Cronbach's α for each index as well as the intercorrelations between the indices separately for times 1 and 2. The correlations between time 1 and time 2 are also reported. As may be seen, the constructed indices have acceptable reliability (Cronbach's α ranging from 0.62 to 0.92). Furthermore, the intercorrelations are as predicted, with the exception of a moderate intercorrelation between the valence and activation indices. As noted by Watson *et al.* (1999), the valence and activation (or engagement as Watson *et al.* label activation) were neither strictly independent of each other in several datasets obtained with the PANAS scales (Watson *et al.*, 1988) or in datasets obtained with the Current Mood scale (Feldman-Barrett & Russell, 1998). Yet this does not necessarily imply that the two underlying theoretical dimensions of the affect circumplex are dependent, since the observed correlations may reflect the influence of various nuisance factors (Russell & Carroll, 1999a). As may also be seen in Table 4, the exclusion of the adjective pair quiet–energetic (*dämpad–energisk*) in the activation index substantially reduces the simple correlation between valence and activation (from 0.35 to 0.19 for the time-1 ratings, and from 0.40 to 0.21 for the time-2 ratings).

Table 3. *Varimax rotated loadings from principal axis factor analysis of adjective ratings at times 1 and 2 (Study 2)*

	Time 1					Time 2				
Adjective pair	*M*	*SD*	Factor 1	Factor 2	h^2	*M*	*SD*	Factor 1	Factor 2	h^2
Dull–peppy	53.3	21.6	−0.21	**0.65**	0.43	50.8	20.4	**0.76**	0.00	0.45
Sleepy–awake	56.2	22.3	−0.12	**0.72**	0.34	54.0	19.5	**0.63**	−0.35	0.31
Quiet–energetic	53.6	18.3	0.67	**0.29**	0.45	54.1	16.5	**0.79**	0.00	0.47
Displeased–pleased	60.0	19.9	**0.77**	0.00	0.54	57.4	17.3	0.64	**0.32**	0.50
Sad–glad	62.1	23.8	**0.84**	0.00	0.55	64.1	16.6	0.52	**0.65**	0.72
Depressed–happy	60.6	21.2	**0.85**	0.00	0.70	58.0	19.7	0.54	**0.60**	0.45
Bored–interested	58.7	16.7	0.66	0.24	0.43	51.0	19.9	0.72	0.17	0.72
Indifferent–engaged	60.1	19.5	0.59	−0.30	0.39	54.0	20.3	0.79	0.00	0.62
Pessimistic–optimistic	66.0	20.2	0.74	−0.22	0.51	59.6	20.7	0.61	0.50	0.41
Tense–serene	60.0	20.6	0.34	0.70	0.37	61.5	20.2	0.00	0.77	0.26
Anxious–calm	62.7	22.1	0.56	−0.69	0.21	60.0	20.4	0.00	0.72	0.52
Nervous–relaxed	63.4	21.8	0.35	0.71	0.40	65.3	20.8	0.00	0.88	0.67
Variance (%)			40.5	17.2	57.7			39.8	26.16	65.9

Note: [a]Values in bold denote loadings for hypothesized valence and activation items.

Table 4. *Means, standard deviations, intercorrelations, and Cronbach's αs[a] for affect indices (Study 2)*

	M	*SD*	A	V	UAPD	PAUD
Time-1 ratings						
Activation (A)	54.3 (54.7[b])	16.1 (19.0)	0.72 (0.89)			
Valence (V)	60.9	19.8	0.35 (0.19)	0.82		
Unpleasant activation–pleasant deactivation (UAPD)	62.0	18.5	0.15 (0.27)	0.33	0.92	
Pleasant activation–Unpleasant deactivation (PAUD)	61.6	18.6	0.61 (0.65)	0.51	−0.16	0.84
Time-2 ratings						
Activation (A)	42.9 (43.4)	15.2 (15.8)	0.62 (0.76)			
Valence (V)	52.8	18.0	0.40 (0.20)	0.79		
Unpleasant activation–pleasant deactivation (UAPD)	72.3	17.7	−0.10 (−0.25)	0.46	0.89	
Pleasant activation–Unpleasant deactivation (PAUD)	54.6	16.8	0.55 (0.66)	0.68	0.24	0.78
$r_{\text{time 1, time 2}}$			0.33 (0.31)	0.63	0.59	0.56

Notes: [a]Cronbach's αs are given in the main diagonal.
[b]Values within parentheses exclude the activation adjective pair quiet–energetic.

That the affect indices were capable of discriminating between mood states was substantiated by dependent *t*-tests yielding significant differences between times 1 and 2, $t(95) = 4.35$, $p < 0.001$ (activation), $t(95) = 4.63$, $p < 0.001$ (valence), $t(95) = 4.49$, $p < 0.001$ (unpleasant activation–pleasant deactivation), and $t(95) = 4.44$, $p < 0.001$ (pleasant activation–unpleasant deactivation). As was expected, both activation and valence were lower at time 1 than at time 2. The observed differences for the other indices simply reflect their correlations with valence and activation.

In summary, the results of Study 2 showed that the bipolar adjective scales developed from the unipolar scales in Study 1 confirmed the two orthogonal dimensions of valence and activation. Four indices with acceptable reliability measuring valence, activation, pleasant activation–unpleasant deactivation, and unpleasant activation–pleasant deactivation were furthermore possible to form from the bipolar scales. These indices were able to discriminate between naturally occurring moods.

STUDY 3

In Study 3 an additional attempt was made to show that the affect indices are capable of discriminating between moods. A procedure was used to induce moods (Gerrards-Hesse, Spies & Hesse, 1994; Lang, 1995; Russell & Mehrabian, 1977, 1978) characterized by different degrees of activation and valence.

Method

Participants. Ninety six undergraduates at Göteborg University, 43 male and 53 females, participated on a voluntary basis. Their mean age was 24.5 years with a SD of 5.3 (range from 19 to 60 years).

Adjective scales. The adjective scales were the same as in Study 2 except that quiet–energetic (*dämpad–energisk*) was replaced due to its low loadings on the activation factor. The scale passive–active (*passiv-aktiv* in Swedish) was instead chosen. The endpoint adjectives defined unipolar scales in Sjöberg *et al*. (1979).

Mood-inducing procedure. An efficient standard method to induce mood is to present participants with different scenarios and to ask them to imagine being in the situation (Gerrards-Hesse *et al*., 1994). Four short descriptions of everyday situations were therefore constructed with the aim of inducing a mood in each of the four quadrants of the affect circumplex. The four descriptions were: "Imagine that you have just got the summer job that you applied for" (pleasant activation); "Imagine that you have just learnt that you failed an exam" (unpleasant activation); "Imagine that you are lying on the beach after a long hot day in the sun" (pleasant deactivation); and "Imagine that you are cleaning your apartment after yesterday's party" (unpleasant deactivation).

Procedure. In a booklet administered to each participant in connection with a lecture, the four mood-inducing situations were described on separate pages. The adjective scales were printed below each description. Instructions asked participants to imagine the described situation, to try to feel the way they would do in this situation, and to use the adjective scales to indicate how they felt. In a within-subjects design, the four descriptions were presented to each participant in different orders arranged according to a latin square. Four different random orders between the rating scales were also used.

Completing the booklet that also contained other unrelated questions took about 15 minutes. Participants were thanked and debriefed afterwards.

Results and discussion

The correlation matrices for each of the four mood-inducing situations were submitted to separate principal axis factor analyses. The scree criterion indicated that two-dimensional solutions were appropriate. As may be seen in Table 5, the activation and valence scales load on different factors in all

Table 5. *Varimax rotated loadings from principal axes factor analyses of bipolar adjective-scale ratings of four different induced moods (Study 3)*

	Induced mood[a]									
	UA[b]		PA		UD		PD		Total[c]	
Adjective Pair	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
Dull–peppy	0.14	**0.86**	0.00	**0.76**	−0.11	**0.78**	0.12	**0.73**	0.22	**0.82**
Sleepy–awake	−0.15	**0.56**	0.00	**0.73**	0.00	**0.82**	0.00	**0.69**	0.19	**0.79**
Passive–active	0.26	**0.75**	0.00	**0.85**	0.19	**0.58**	−0.11	**0.69**	0.35	**0.68**
Displeased–pleased	**0.76**	0.00	**0.69**	0.39	**0.49**	0.39	**0.80**	0.28	**0.91**	0.00
Sad–glad	**0.64**	0.14	**0.67**	0.05	**0.68**	0.37	**0.83**	0.00	**0.92**	0.00
Depressed–happy	**0.82**	0.00	**0.67**	0.35	**0.54**	0.35	**0.60**	0.00	**0.90**	0.00
Bored–interested	0.14	0.80	0.34	0.74	−0.18	0.59	0.42	0.44	0.57	0.59
Indifferent–engaged	0.00	0.78	0.13	0.79	0.26	0.61	0.22	0.58	0.38	0.72
Pessimistic–optimistic	0.64	0.34	0.74	0.39	0.58	0.12	0.65	0.26	0.90	0.00
Tense–serene	0.77	0.00	0.71	−0.25	0.82	0.00	0.90	0.00	0.64	−0.63
Anxious–calm	0.80	0.02	0.86	0.00	0.74	−0.14	0.89	0.00	0.74	−0.51
Nervous–relaxed	0.70	0.00	0.67	−0.16	0.74	−0.14	0.91	0.00	0.61	−0.61
Variance (%)	33.8	25.1	40.5	22.1	31.2	20.3	41.3	17.0	44.6	30.4

Notes: [a]The induced moods are unpleasant activation (UA), pleasant activation (PA), unpleasant deactivation (UD), and pleasant deactivation (PD).
[b]Values in bold denote loadings for hypothesized valence (factor 1) and activation (factor 2) items.
[c]Based on the total number of observations by combining individual and mood variance.

analyses, thus indicating that the scales reliably tap the two dimensions. Following the procedure in Watson and Tellegen (1999), individual and mood variance was combined in an additional analysis performed on all individuals' ratings of all four situations. This analysis confirmed the two-dimensional solution, with more variance accounted for by the two factors as compared to the separate analyses. As in Studies 1 and 2, four affect indices corresponding to each of activation, valence, pleasant activation–unpleasant deactivation, and unpleasant activation–pleasant deactivation were constructed by summing across the three rating scales assumed to measure each dimension. Table 6 shows means, standard deviations, intercorrelations, and Cronbach's alphas for each of the induced moods.

Indicating that the affect indices discriminated between the different moods, one-way repeated-measures analyses of variance (ANOVAs) yielded highly significant effects (after Geisser–Greenhouse correction of the d.f.s), $F(2.88, 93.22) = 114.92$, $p < 0.001$ (activation), $F(2.90, 93.10) = 435.12$, $p < 0.001$ (valence), $F(2.58, 93.42) = 133.92$, $p < 0.001$ (unpleasant activation–pleasant deactivation), and $F(2.82, 93.18) = 119.11$, $p < 0.001$ (pleasant activation–unpleasant deactivation). As Figure 4 shows, the induced moods are positioned in the affect space roughly as hypothesized. Bonferonni-corrected post hoc *t*-tests showed that on valence all mean differences were significant except the difference between pleasant deactivation and pleasant activation. On activation all the differences between the means were significant except the difference between pleasant deactivation and unpleasant deactivation. It is thus concluded that the adjective ratings discriminated between different induced moods.

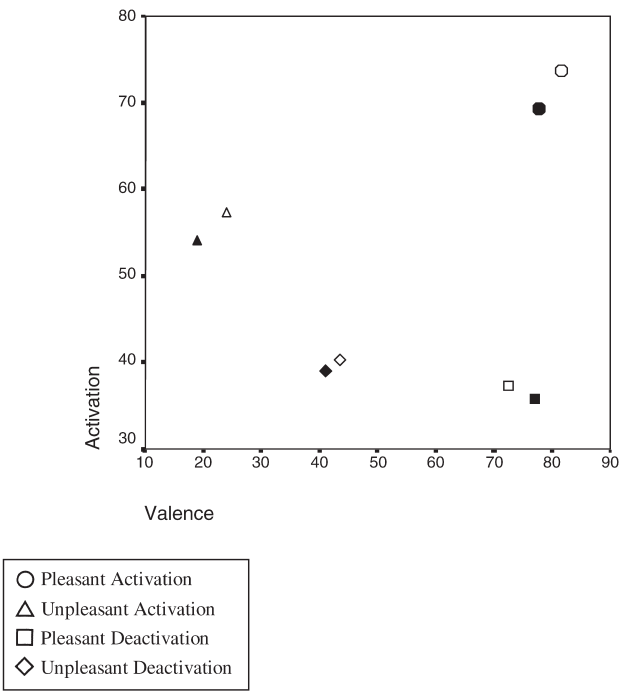

Fig. 4. Mean and group bipolar adjective scale ratings of induced moods (Study 3). (Filled symbols denote subgroup means, unfilled symbols denote total means.)

An additional analysis was performed in which the participants were split into four approximately equally large groups depending on which mood was induced first. As Figure 4 shows, the means of the first ratings by each group indicated that the results were very similar as for the means

Table 6. *Means, standard deviations, intercorrelations, and Cronbach's αs[a] for affect indices constructed from bipolar adjective-scale ratings of induced moods (Study 3)*

	M	*SD*	A	V	UAPD	PAUD
Unpleasant activation						
Activation (A)	58.9	29.9	0.89			
Valence (V)	36.1	27.2	0.14	0.95		
Unpleasant activation–pleasant deactivation (UAPD)	37.2	24.4	0.13	0.57	0.91	
Pleasant activation–unpleasant deactivation (PAUD)	44.8	18.7	0.60	0.37	0.31	0.78
Pleasant activation						
Activation (A)	72.7	13.7	0.79			
Valence (V)	80.9	13.4	0.20	0.91		
Unpleasant activation–pleasant deactivation (UAPD)	52.3	18.7	0.30	0.28	0.88	
Pleasant activation–unpleasant deactivation (PAUD)	76.1	11.6	0.57	0.72	0.27	0.80
Unpleasant deactivation						
Activation (A)	37.6	15.5	0.81			
Valence (V)	41.8	12.6	0.31	0.85		
Unpleasant activation–pleasant deactivation (UAPD)	63.3	17.5	0.07	0.32	0.92	
Pleasant activation–unpleasant deactivation (PAUD)	41.4	11.6	0.47	0.47	0.12	0.85
Pleasant deactivation						
Activation (A)	35.8	15.3	0.90			
Valence (V)	73.3	12.6	0.06	0.90		
Unpleasant activation–pleasant deactivation (UAPD)	81.6	12.9	0.27	0.77	0.83	
Pleasant activation–unpleasant deactivation (PAUD)	56.9	13.0	0.21	0.56	0.33	0.90
Total[b]						
Activation (A)	50.4	21.4	0.82			
Valence (V)	56.3	27.4	0.29	0.95		
Unpleasant activation–pleasant deactivation (UAPD)	58.0	22.1	−0.15	0.56	0.85	
Pleasant activation–unpleasant deactivation (PAUD)	55.4	20.1	0.67	0.64	0.24	0.90

Notes: [a]Cronbach's αs are given in the main diagonal.
[b]Based on the total number of observations by combining individual and mood variance.

across all participants. One-way ANOVAs yielded significant differences on all indices, $F(3, 95) = 26.77$, $p < 0.01$ (activation), $F(3, 95) = 139.59$, $p < 0.01$ (valence), $F(3, 95) = 39.77$, $p < 0.01$ (unpleasant activation–pleasant deactivation), and $F(3, 95) = 24.68$, $p < 0.01$ (pleasant activation–unpleasant deactivation). Tukey post hoc tests showed that on valence, all mean differences were significant except the difference between pleasant deactivation and pleasant activation. On activation all mean differences were significant except the difference between pleasant deactivation and unpleasant deactivation. Thus, the results indicate that the scales also discriminate between individuals.

GENERAL DISCUSSION

In three studies it was shown that the adjective-scale ratings could be represented as a circumplex structure with the hypothesized dimensions of valence and activation. In addition, aggregated bipolar adjective ratings were demonstrated to be reliable and sensitive measures of these dimensions as well as of two dimensions rotated 45 degrees to them, labeled pleasant activation–unpleasant deactivation and unpleasant activation–pleasant deactivation. These results largely confirm the circumplex model of the structure of core affects (Feldman Barrett & Russell, 1998; Larsen & Diener, 1992; Russell, 1980). At the same time the results cross-validate findings in previous research in other countries (Feldman, 1995a, 1995b; Feldman Barrett, 1996, 1998; Russell, 1983, 1991; Russell & Feldman Barrett, 1999; Russell, Lewicka & Niit, 1989).

A tangible outcome of the current research is a new self-report measure of core affects (the Swedish Core Affect Scale or SCAS) that can be used in a Swedish-language context for many applications, for instance in research on judgment

and decision making (Mellers, Schwartz & Ritov, 1999; Västfjäll, Gärling & Kleiner, 2001), social psychology (Martin, Abend, Sedikies & Green, 1997), affective neuroscience (Ito & Cacioppo, 1999), and applied areas such as environmental psychology (e.g., Hartig Böök, Garvill, Olsson & Gärling, 1996; Hartig, Nyberg, Nilsson & Gärling; 1999) and consumer satisfaction (Friman, 2002). In any application of this measure, each adjective rating scale may be used for fine-grained assessments of core affects. However, it is frequently desirable to form indices. A simple algorithm would then be to sum the ratings across sets of scales that are close to each other in the circumplex. Such a scoring algorithm used in Studies 1–3 resulted in reliable measures of valence, activation, pleasant activation–unpleasant deactivation, and unpleasant activation–pleasant deactivation. A more parsimonious method is, however, to obtain a measure of valence and another uncorrelated measure of activation, since any combination of valence and activation is sufficient to describe a given core affect. In fact, a two-dimensional graphical scale with the dimensions valence and activation was proposed early by Russell, Weiss and Mendelsohn (1989). Thus, the ratings may instead be summed to obtain two indices. This can be achieved by splitting the ratings in two sets so that ratings moderately to highly correlated with valence are summed to a valence index, while ratings moderately to highly correlated with activation are summed to an activation index. In this way Feldman Barrett and Russell (1998) obtained close to independent composite indices of valence and activation. Using this method, Västfjäll *et al.* (2001, Experiment 1) found a low correlation between the indices and satisfactory Cronbach's α.

Another method of obtaining two indices is to sum the ratings using weights corresponding to the angles that the adjective-scale ratings form relative to a reference vector. This is similar to calculating factor scores, although factor loadings need not be estimated (Russell, 1980; Sjöberg *et al.*, 1979). Avoiding this is advantageous since it cannot be ruled out that the factor loadings vary across samples and conditions. Also, sample sizes may frequently be too small to allow the derivation of indices based on factor loadings. Instead, it is proposed that the ratings of adjectives closely corresponding to each of the four dimensions of valence, activation, pleasant activation–unpleasant deactivation, and unpleasant activation–pleasant deactivation are assigned weights that reflect their correlations with each other. Valence adjective ratings are assumed to correlate perfectly with valence and are thus given the weight 1 (and the weight 0 in the activation index), whereas activation adjective ratings are assumed to have a zero correlation with valence and are thus given the weight 0 (and the weight 1 in the activation index). Adjective scale ratings tapping the intermediate dimensions pleasant activation–unpleasant deactivation and unpleasant activation–pleasant deactivation are assumed to yield a positive or negative correlation of 0.71 with valence and activation. In summing adjective ratings to form the valence and activation indices, these correlations are used as weights. The proposed weights (see Table 7) were applied to the ratings in Study 3. The correlation between the two weighted indices was 0.01 and Cronbach's α were 0.93 (valence) and 0.86 (activation), respectively. This should be compared with the simple indices only containing activation or valence adjective ratings with an intercorrelation of 0.29 and Cronbach's α of 0.95 (valence) and 0.82 (activation), respectively.

The present research used a response format that in principle corresponded to a standard nine-point scale, allowing respondents to use decimals. Previous research does not indicate that standard bipolar response format significantly

Table 7. *Final selection of adjective pairs in the Swedish Core Affect Scale (SCAS) and weights applied in forming indices of valence and activation*

	Adjective pairs		Weights	
Affect index[a]	English	Swedish	Valence	Activation
Valence	displeased–pleased	missnöjd–belåten	1	0
	sad–glad	ledsen–glad	1	0
	depressed–happy	nedslagen–munter	1	0
Activation	sleepy–awake	sömnig–vaken	0	1
	dull–peppy	slö–pigg	0	1
	passive–active	passiv–aktiv	0	1
Pleasant activation–unpleasant deactivation	bored–interested	uttråkad–intresserad	0.7	0.7
	indifferent–engaged	oengagerad–engagerad	0.7	0.7
	pessimistic–optimistic	pessimistisk–optimistisk	0.7	0.7
Unpleasant activation–pleasant deactivation	tense–serene	spänd–avspänd	−0.7	0.7
	anxious–calm	orolig–lugn	−0.7	0.7
	nervous–relaxed	nervös–avslappnad	−0.7	0.7

Note: [a]The indices are computed as Σ(weight × adjective scale rating).

changes the results (Russell & Carroll, 1999a). Confirming this, Västfjäll and Gärling (2002) showed that valence and activation ratings obtained with the response format used in the present research did not differ from ratings obtained on bipolar 1 to 9 or –4 to 4 scales.

The affect circumplex represents a parsimonious and heuristic taxonomy of affect but is limited to core affects (Russell & Feldman Barrett, 1999). Starting with the assumption that core affects are components of prototypical emotional episodes, the affect circumplex has recently been extended to a three-dimensional model (Russell & Feldman-Barrett, 1999). In this model it is assumed that core affects are described by valence and activation. However, a third dimension, breadth of experience, is needed when going beyond core affects. This third dimension is assumed to differentiate affect states or emotions that have the same position in the affect circumplex. The dimension would thus account for appraisal, action tendencies, experience, and behavior that, in conjunction with core affects, constitute prototypical emotional episodes. Other measures than those developed in the present study are needed to assess the third dimension for describing emotional episodes. Such measures have been developed and used by, among others, Frijda, Kuipers and ter Schure (1993), Lazarus (1991), Wallbott and Scherer, (1989), Roseman, Antoniou and Jose (1996), and Smith and Ellisworth (1985). An extension of the affect circumplex to account for emotional episodes is a much needed step, although beyond the scope of the present paper.

Another attempt at extending the affect circumplex has recently been published by Tellegen, Watson and Clark (1999a, 1999b). Drawing on research on positive and negative affect or activation (Watson and Tellegen, 1985), Watson *et al.* proposed a hierarchical model with bipolar pleasantness–unpleasantness at the top level, positive and negative affect at the intermediate level, and discrete emotions at the bottom level. The tenet is that pleasantness–unpleasantness (or valence) at the top level is fundamental to all affective experience. At the second level pleasantness or unpleasantness are transformed to positive or negative affect, respectively. Following negative or positive affect, discrete emotions like sadness, anger, happiness, or guilt are experienced. This model fails, however, to explicitly account for components extrinsic to core affect. Russell and Feldman Barrett's (1999) model, on the other hand, provides tentative guidelines for how to describe emotions with respect to such extrinsic components. Through operationalization of the proposed third dimension that they add to the affect circumplex, a better understanding of emotions may be achieved. An understanding of the structure of core affects is, however, still an important ingredient.

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NOTE

[1] A more recent study (Knez & Hygge, 2002) tested a Swedish translation of Larsen and Diener's (1992) 48 unipolar adjective scales.

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