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A 12-Point Circumplex Structure of Core Affect

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Core Affect is a state accessible to consciousness as a single simple feeling (feeling good or bad, energized or enervated) that can vary from moment to moment and that is the heart of, but not the whole of, mood and emotion. In four correlational studies (*N*s = 535, 190, 234, 395), a 12-Point Affect Circumplex (12-PAC) model of Core Affect was developed that is finer grained than previously available and that integrates major dimensional models of mood and emotion. Self-report scales in three response formats were cross-validated for Core Affect felt during current and remembered moments. A technique that places any external variable into the 12-PAC showed that 29 of 38 personality scales and 30 of 30 mood scales are significantly related to Core Affect, but not in a way that revealed its basic dimensions.

Keywords: circumplex, core affect, mood, emotion

Psychology is increasingly turning to the study of mood and emotion, both because of their intrinsic interest and because of their influence on other processes from simple reflexes to complex cognitions to memory to economics to health and well-being. For reasons outlined elsewhere (Russell, 2003a; Russell & Barrett, 1999; Yik, Russell, & Barrett, 1999), we focus our study on that part of mood and emotion called Core Affect. By limiting our topic to Core Affect, we narrow our scope but, we hope, gain in clarity. We offer here a new, finely grained descriptive structure of Core Affect, the 12-Point Affect Circumplex (12-PAC), shown schematically in Figure 1, so that Core Affect and its relationship to other psychological processes can be delineated in a more precise way.

Core Affect

Core Affect is "that neurophysiological state consciously accessible as the simplest raw (nonreflective) feelings evident in moods and emotions" (Russell, 2003a, p. 148). By "simplest feelings," we mean that Core Affect cannot be reduced to anything simpler at a psychological level, although of course it can at a neurophysiological level. In this article, we examine the psychological rather than the neurophysiological level (for the latter, see Gerber et al., 2008; Posner, Russell, & Peterson, 2005). Specifically, we examine verbally reported feelings during brief slices of time.

The term "Core Affect" was coined to help distinguish what is represented by our proposed structure and its predecessors from such everyday terms as *emotion* and *mood*. Core Affect is a component of discrete emotional episodes, but not the whole of them. Unlike an "emotion," Core Affect is not necessarily directed at a specific object, although it can become so. Core Affect, when changing rapidly, directed at an object, and accompanied by certain cognitions, physiological changes, and behaviors, is part of what in English is called "emotion." Anger and fear, for example, are not simply Core Affect, but rather sequences of subevents, only one of which is a change in Core Affect. Thus, from our perspective, a specific actual case of fear and one of anger could have identical states of Core Affect, but differ in other components.

Core Affect is also a part—but *only* a part—of what in English is called "mood." The everyday concept of mood implies a prolonged experience, often relatively mild, with behavioral demeanor, thoughts, and motivation. For example, in everyday English, an anxious mood implies Core Affect of unpleasant arousal that endures for a long period with the likelihood of worried thoughts, vigilant behavior, and the motive to avoid risk. In contrast, Core Affect is defined solely as a single feeling at a slice in time, and its duration, intensity, and relation to behavior, thoughts, and motivation are treated as empirical issues. Thus, whereas "mood" is defined in a way that a person is sometimes in a mood and sometimes not, a person always has Core Affect. Although Core Affect varies in its salience in consciousness, it is always potentially accessible: whenever asked, people can tell you how they feel.

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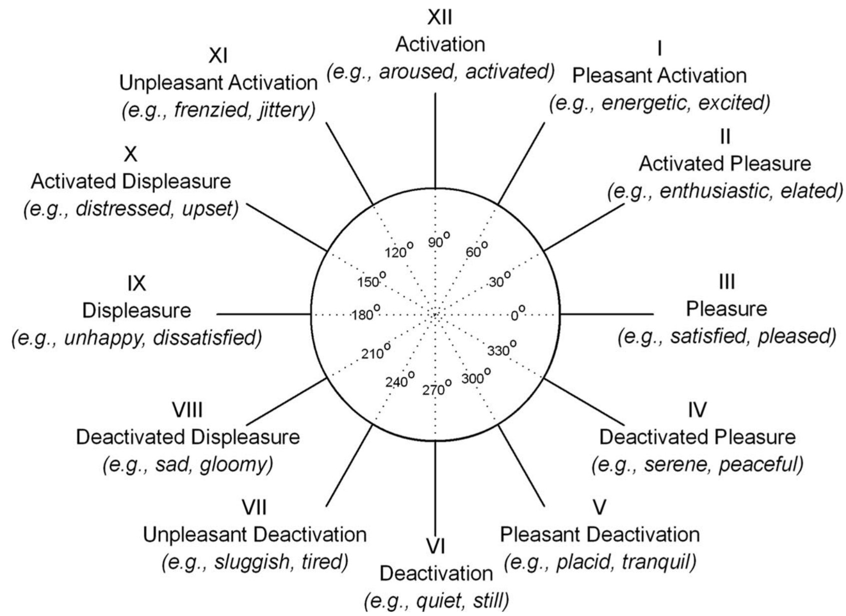


Figure 1. A 12-Point Affect Circumplex (12-PAC). Figure shows a schematic diagram of the hypothetical locations of the 12 segments of Core Affect.

Structure of Core Affect

Something like Core Affect is supported by various lines of evidence and theorizing, including studies of the semantic differential, introspection, psychophysiology, neuroscience, behavioral processes, facial expression, and linguistics (Russell, 2003a). Still, the structure of Core Affect is seen most clearly in psychometric studies of self-reported experiences of mood, emotion, and everyday feelings. Descriptive structures derived from such studies can be classified into three general types: categories, dimensions, and circumplexes.

Categorical structures, often with the categories arranged in a hierarchy, have a long history and are based on the everyday folk lexicon, which identifies discrete types of moods and emotions: fear, anger, jealousy, anxiety, depression, and so on. Assessment tools derived from this perspective include mood or emotion adjective checklists (Izard, 1971; McNair, Lorr, & Droppleman, 1971; Nowlis, 1965; Zuckerman & Lubin, 1965). Categories of mood and emotion are typically more highly correlated with each other than is readily predictable from theories of discrete categories. We believe that these intercorrelations stem largely from shared Core Affect, as in the example of anger and fear above. In this sense, a structure of Core Affect complements rather than competes with categorical structures.

Dimensional structures of mood and emotion have a similarly long history. One traditional structure consists of two orthogonal bipolar dimensions, variously named, but always similar to valence (pleasure-displeasure, positive-negative) and arousal (arousal-sleepiness, high-low activation) (Feldman, 1995; Heller, 1990; Lang, 1978; Larsen & Diener, 1992; Mehrabian & Russell, 1974; Reisenzein, 1994; Russell, 1980). Thayer (1989) proposed four dimensions of activation. Watson and Tellegen (1985) proposed two dimensions of valence, originally named Positive and Negative Affect, but then changed to Positive and Negative Activation (Watson, Wiese, Vaidya, & Tellegen, 1999). Similar models were proposed by others (Mayer & Gaschke, 1988; Morris, 1989). As the names of the principal dimensions of these various models suggest, they all seem so similar that they are ripe for integration. One proposal along these lines (Russell, 1979; Larsen & Diener, 1992; Watson & Tellegen, 1985)—called the 45° rotation hypothesis—is that the principal dimensions in these various models all fit within the same two-dimensional space with 45° between major dimensions, as shown in the schematic diagram inside the circle of Figure 2. Integration among dimensional models is a topic we address in Study 1.

Circumplex structures—in which the intercorrelations among variables are represented by a circle—of mood and emotion have a shorter history, but have obtained empirical support (Fabrigar, Visser, & Browne, 1997; Remington, Fabrigar, & Visser, 2000; Yik, 2009b; Yik, Russell, Ahn, Fernández Dols, & Suzuki, 2002). The circumplex complements rather than competes with a dimensional perspective on mood and emotion, although traditionally the dimensional perspective emphasizes simple structure as a means of identifying the underlying dimensions. In contrast, a simple plot of moods and emotions within the Cartesian space formed by those underlying dimensions suggests a circular rather than simple structure. Recently, the circumplex as a model of mood and emotion has been the focus of attention (Green, Salovey, & Truax, 1999; Russell & Carroll, 1999; Watson et al., 1999), but one should not write of "the" circumplex. Historically, different circumplicial structures have been offered (Plutchik, 1962; Russell, 1980; Schlosberg, 1941; Watson & Tellegen, 1985), and in this article we offer a new version. For two decades, most writers in this field have taken "the" circumplex to be what is shown inside the circle of Figure 2: eight variables equally spaced within a two-dimensional structure. Theoretical gears have been in neutral, and it is time to consider new possibilities.

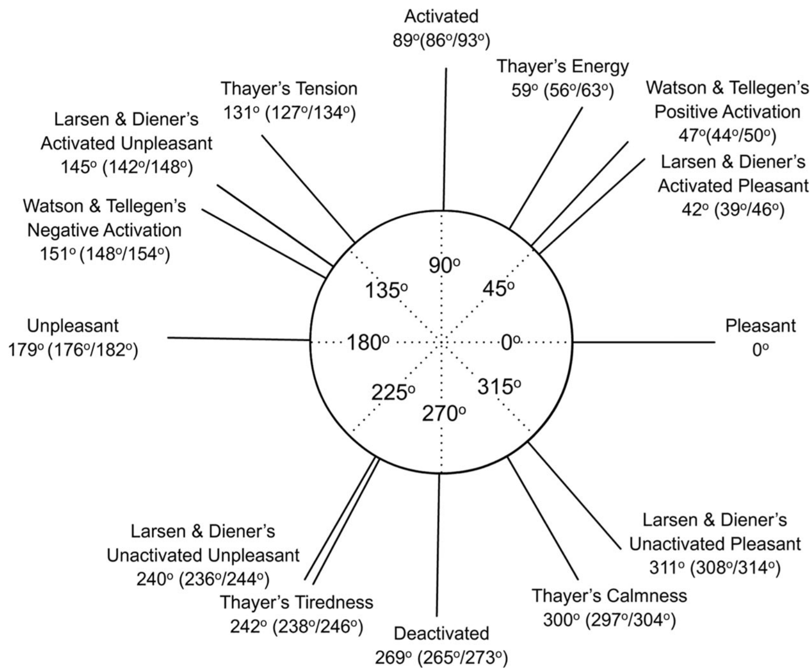


Figure 2. Integration of Dimensional Models of Mood and Emotion. Eight vectors 45° apart inside the circle represent the 45°-rotation hypothesis. Outside the circle is an empirical circumplex representation of 14 constructs created by CIRCUM. Figures given are estimates of polar angles with the 95% confidence intervals in parentheses (Study 1; $N = 535$).

Need for a New Circumplex Structure

The concept of Core Affect helps clarify why categories of mood and emotion are interrelated as they are, why two dimensions of mood and emotion are ubiquitous in this field, why a circumplex provides a revealing but parsimonious representation of the correlational structure of mood and emotion, and yet why categories of mood and emotion are not fully accounted for by a two-dimensional or circumplicial structure. But the concept of Core Affect can do so only when represented in a detailed descriptive structural model. We believe that the description of Core Affect can be further clarified by examining more dimensions, each more narrowly defined. Finer distinctions can then be made between seemingly similar constructs, and Core Affect can be described and assessed using an entire structure rather than a few dimensions or categories.

One problem has been that dimensions of mood and emotion (and the scales derived from them) have often been defined by just a few overly broad clusters of diverse states. For example, Watson and Tellegen's (1985) Positive Affect includes feelings of alertness and happiness—which are clearly different from one another and are found in different places within the structure of Figure 1. Similarly, Watson and Tellegen's Negative Affect includes feelings of upset, unhappiness, and sadness—which are also clearly different from one another and are found in different places in the structure of Figure 1. A circumplex is well suited to representing a domain in which states are both similar to but slightly different from each other. Defining narrower slices of the space clarifies the nature of that space and of the items within it. For example, in the model to be proposed here (see Figure 1), items *alert* and *happy* fall in two separate but nearby clusters; items *upset*, *unhappiness*, and *sadness* fall into three separate but nearby clusters. Thus, a finer grained model helps describe and clarify even subtle differences in descriptors.

Charting the Relation of Core Affect to Other Variables

Another advantage of a finer-grained analysis is that it can help clarify the relation of Core Affect to other variables. Consider attempts to locate the basic dimensions of affect by examining external variables—attempts that have resulted in conflicting claims. Mehrabian and Russell (1974) hypothesized and offered evidence that the personality traits of Extraversion and Neuroticism correspond to, respectively, the pleasure and the arousal dimensions of Core Affect. By "correspond to" is meant that the same processes underlie both. Operationally, by "corresponds to" is meant that Extraversion is highly correlated with the dimension of Core Affect at 0° but lowly correlated with the dimension at 90° in the space of Figure 2. Conversely, Neuroticism is highly correlated with the dimension 90° and lowly correlated with the dimension at 0°. In contrast to Mehrabian and Russell's hypothesis, Meyer and Shack (1989) and Tellegen (1985) hypothesized and offered evidence that Extraversion and Neuroticism correspond instead to, respectively, the dimensions of Core Affect at 45° and 135° (dimensions named Positive and Negative Activation by Watson et al., 1999). Watson et al. (1999) also argued that Gray's (1981, 1994) Behavioral Activation System and Behavioral Inhibition System correspond to their Positive Activation and

Negative Activation, respectively. This claim complicates the issue because Gray's (1981) argued that his two behavioral systems are 45° away from Extraversion and Neuroticism. These alleged correspondences were used to argue for the biological basis and therefore "basicness" of a specific rotation of the space of Figure 2.

Empirical results have not resolved the controversy (Larsen & Diener, 1992; Yik & Russell, 2001; Yik et al., 2002). One reason is that the prediction of a "high correlation" or a "low correlation" is imprecise. Extraversion, for example, can have a "high correlation" with more than one variable of Core Affect and a "low correlation" with more than one, leaving room for many "correspondences." A related problem is that the dimensional perspective traditionally focused on just a few locations within the affect space (multiples of 45°), leaving many possibilities unexplored. Progress on these conflicting claims awaits an examination of all locations within the affect space. The circumplex allows the personality variable—or any other external variable—to fall at any angle within the space rather than "correspond to" one of the named dimensions. A circumplex analysis therefore raises the question of the precise placement in the space of all the various personality dimensions. The circumplex perspective replaces the notion of "high" and "low" correlations with the question of the precise correlation of the personality variable at each location within the circumplex. Here we describe a technique for answering this question.

The circumplex provides a simple but powerful mechanism for charting the relationship between Core Affect and any external variable (i.e., a variable not included within the 12-PAC), such as a personality scale. The principle is that any external variable that correlates with one Core Affect variable will correlate with all the remaining Core Affect variables in a systematic way: the magnitude of that correlation rises and falls in a cosine wave pattern as one moves around the circumference of the circumplex (e.g., Stern, 1970; Wiggins, 1979). Rather than assume that the external variable correlates with only one of the principal axes (or falls at a multiple of 45°), researchers are forced to be open to any location. Rather than examine the correlation of that external variable to one existing Core Affect dimension at a time, researchers can instead estimate the precise location of that external variable within the entire circumplex—and hence with all Core Affect variables simultaneously—even when no variable is currently defined at that specific location. The presence of a relation between an external variable and Core Affect space can best be detected by the presence of a cosine wave rather than by the magnitude of an individual correlation; statistical tests will therefore become more powerful because they are based on more data.

In our finer-grained circumplex of Core Affect, the target angle between dimensions is 30° rather than 45°. The resulting 12 variables provide a level of precision that allows a better estimate of where within the space lies any variable, whether it is part of or external to Core Affect. Success of a finer grained model would also challenge the implicit assumption that Core Affect space is divisible into precisely eight equally spaced slices and that the number of interpretable rotations of the space is exactly two (0° and 90° vs. 45° and 135° in the inner circle of Figure 2). If a 12-point circumplex fits the data, then presumably the space can be carved into more or fewer slices, and the number of segments is a matter of convenience. The space can be rotated in any number of ways; indeed, the best rotation may not be resolvable through psychometric means alone. Rotation of the principal axes, and thus some hint as to the location of underlying mechanisms, is not limited to multiples of 45°. The search for simple structure may therefore not be useful. Although, for convenience, we strive for equally spaced variables, equal spacing is not required for a circumplex. With a 12-point circumplex, Core Affect space is described in more detail, but the overall structure remains highly parsimonious.

Goals of the Present Studies

In developing our descriptive structure, we hoped to make advances on a number of fronts. First, we pursued the integration of the major dimensional models of mood and emotion, namely, Russell's (1980) pleasure and arousal, Thayer's (1996) tense and energetic arousal, Larsen and Diener's (1992) eight different combinations of pleasantness and activation, and Watson and Tellegen's (1985) positive and negative affect. We further built up the nomological net of the 12-point structure by integrating other mood scales, including Mehrabian and Russell's (1974) semantic differential scales, and Quirin, Kazén, Rohrmann, and Kuhl's (2009) measures of "implicit affect."

Second, we constructed a new circumplex structure of Core Affect. To do so, we developed verbal self-report scales for our 12 variables in a large sample and provided cross-validating evidence on their structural and psychometric properties in three additional data sets, each based on a somewhat different recall method.

Third, we examined a large selection of external variables through our cosine wave technique, which, we also showed, approximates a more sophisticated analysis known as the "CIRCUM-extension" method (M. Browne, personal communication, June 12, 1999). The two procedures allowed us to reexamine the idea that external correlates can identify the "basic" axes of mood and emotion. Return to the controversy mentioned earlier over the proper rotation of affect space as determined by, for example, a correspondence among Positive Activation, Extraversion, and Behavioral Activation System, on the one hand, and among Negative Activation, Neuroticism, and Behavioral Inhibition System, on the other. Larsen and Diener (1992; see also Yik, 2009b; Yik et al., 2002) argued that, empirically, personality variables tend to fall all around the circumplex rather than cluster at 45° and 135°. Personality correlates therefore failed to specify the location of basic axes. Here, we reexamined this issue with several comprehensive personality taxonomies. The cosine wave technique allowed us to move beyond a test of the significance of zero-order correlations to the calculation of precise angles within the Core Affect space.

Overview of Present Studies

To advance toward these goals, we carried out four studies. In each, participants reported how they were feeling during a brief slice in time. Instructions in which participants are asked to describe feelings "today" or "this week" are not suitable because Core Affect can vary from moment to moment; participants describing the feelings of an entire day or week are therefore making some sort of complicated judgment integrating fluctuating momentary feelings into a single rating (Robinson & Clore, 2002). Instructions to describe current feelings ("right now") are suitable, but when used with a long questionnaire (such as that required here) create two problems. First, all participants are typically placed in a similar situation, namely, sitting in the investigator's laboratory calmly responding to a questionnaire about their current feelings. The common setting may reduce differences among individuals, and the resulting feelings likely are mild: this restricted range might limit the magnitude of resulting correlations and the external validity of the findings. The second problem is that instructions are often ambiguous, with the possibility that responses describe feelings as they change over the course of the long questionnaire (a participant might honestly report feeling interested at the beginning of the session and bored at the end).

Across the four studies we report here, participants were asked to focus on a single moment. We sampled those moments in different ways in different studies: participants described how they felt during a clearly remembered moment, during a current moment outside our lab, and during a current moment while in our lab. No one method is necessarily superior to the others, but similarity of results across these methodological differences speaks to the robustness to our 12-point structure. An overview of the four studies is given in Table 1.

Study 1: Integration of Old Structures and Creation of a New One

In Study 1, participants completed a battery of questionnaires about how they felt at a single point in time. The questionnaires included items so that dimensions defined by Barrett and Russell (1998), Thayer (1996), Larsen and Diener (1992), and Watson and Tellegen (1985) could be scored. We sought to integrate these four structures into one. We then used the same data to create scales for a new, 12-point circumplex (the 12-PAC) that represents the integrated structure, which we interpret as representing Core Affect.

Participants were asked to remember a specific moment from the previous day and to describe how they were feeling at that moment. A time of day was randomly assigned to each participant in a way that roughly spread those moments across the entire day. In this way, although the questionnaire was long, the participant was focused on a single moment during an ordinary day, specifically a day that did not include participation in this study. This "remembered moments" method is not better than, but complements, the more typical methods and has the advantage that the moments so sampled are likely to be more representative of experiences in the external nonlaboratory world. Its disadvantage is its reliance on memory. To minimize this disadvantage, participants were asked to select a specific moment that was well remembered, and mealtimes were used as memoric anchors (Larsen & Fredrickson, 1999). Our method mirrored Kahneman, Krueger, Schkade, Schwarz, and Stone's (2004) Day Reconstruction Method, which was found to yield results in reported feelings similar to those collected with experience sampling. We return to questions pertinent to the "remembered moments" method in the General Discussion section.

Method

Participants

Participants were 535 undergraduates (241 men and 294 women) of a large Canadian university. They were enrolled in various psychology courses and received course credit for their participation.

Procedure

The front page of the battery provided general instructions under the title "Remembered Moments Questionnaire." Participants were asked to recall a specific moment from yesterday. There were six versions of the questionnaire, each with a different anchoring time: "before breakfast," "after breakfast," "before lunch," "after lunch," "before dinner," and "after dinner." Participants were randomly assigned to one of the six versions. For instance, the instructions for the "before breakfast" version were as follows:

". . . we need to ask you to remember a particular moment. Please think back to yesterday. Specifically, recall the time just *before breakfast.* (If you didn't have *breakfast* yesterday, simply recall that approximate time of day.)

It is important that you remember a specific moment accurately. So, please search your memory and try to recall where you were, what you were doing at that time, who you were with, and what you were thinking.

Now select a particular moment that is especially clear in your memory. (If you really have no recollection of the time just *before*

Table 1
Overview of the Four Studies

Study	*N*	Sample of affect moments	Goal
1	535	Affect felt during a remembered moment	a. Integration of 4 structural models of affect b. Creation of the 12-Point Affect Circumplex (12-PAC) c. Examination of the relations of the 12-PAC to 10 mood scales
2	190	Affect felt during a current moment	Cross-validation of the 12-PAC
3	234	Affect felt during a current moment	a. Cross-validation of the 12-PAC b. Examination of the relations of the 12-PAC to 20 mood scales and 13 personality scales
4	395	Affect felt during two remembered moments	a. Cross-validation of the 12-PAC b. Examination of the relation of the 12-PAC to 25 personality scales

breakfast, please search your memory for the closest time that you do recall accurately.)"

In the other five versions, italicized words were replaced. The instructions then emphasized that all subsequent questionnaires were to be answered with respect to that selected moment of the day before.

Measures

The first questionnaire was the state version of Mehrabian and Russell's (1974) Pleasure and Arousal scales in a semantic differential format. The remaining three questionnaires were similar to each other in content but varied in response format: (a) Adjective format, abbreviated ADJECTIVE, which was a list of adjectives with which participants were asked to describe their feelings, ranging from 1 (*not at all*) to 5 (*extremely*); (b) "Agree-Disagree" format, abbreviated AGREE, which was a list of statements with which participants were asked to indicate their degree of agreement, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*); and (c) "Describes Me" format, abbreviated DESCRIBE, which was a list of statements, for each of which participants were asked to indicate how well it described their feelings, ranging from 1 (*not at all*) to 4 (*very well*).

Items for the latter three questionnaires were based on (a) Barrett and Russell's (1998) Current Mood Questionnaire assessing Pleasant, Unpleasant, Activated, and Deactivated; (b) Larsen and Diener's (1992) Activated Unpleasant, Unactivated Unpleasant, Activated Pleasant, and Unactivated Pleasant; (c) Thayer's (1996) Energy, Tiredness, Tension, and Calmness; and (d) Watson, Clark, and Tellegen's (1988) Positive Affect and Negative Affect. ADJECTIVE items were taken directly from the authors. AGREE and DESCRIBE statements were constructed with same or similar emotion words. To represent areas within the two-dimensional space that are sparsely populated by items, we added 29 new items: 14 in the ADJECTIVE format, eight in the AGREE format, and seven in the DESCRIBE format. There were altogether 75 ADJECTIVE items, 61 AGREE items, and 55 DESCRIBE items.

Data Analysis

Correlation matrices for manifest variables were submitted to structural equation modeling using SEPATH in Statistica (Steiger, 1995). To examine circumplexity, we used RANDALL (Tracey, 1997) and CIRCUM (Browne, 1992). RANDALL applies Hubert and Arabie's (1987) randomization test to examine a circular model's fit to the data. CIRCUM implements Browne's tests of a circular stochastic model of the circumplex and provides maximum likelihood estimates of model parameters.

Along with most researchers (Bollen & Long, 1993), we believe that no single measure of fit for structural models should be relied on exclusively, and we therefore report multiple indexes. Each index is associated with underlying statistical assumptions; each has its strengths and weaknesses. Hypothesized models should not be accepted or rejected on the basis of fixed cutoff points. Rather, hypothesized models should be viewed as candidates to understand what the underlying structures are. Rather than strictly true or false, alternative models vary in terms of reasonableness. These indexes are useful as overall guidelines and best used as comparative indices comparing nested models. (We return to questions of model fit in the General Discussion section.)

SEPATH. For SEPATH analyses, completely standardized solutions were obtained. Thus, both latent and manifest variables are scaled to a variance of 1. In a confirmatory factor analysis model, we estimated: (a) factor loading between each manifest variable and its intended latent construct, (b) error variance associated with each manifest variable, (c) correlation between error terms with the same response format, and (d) correlations between latent constructs. In a structural equation model, we estimated: (a) factor loading between each manifest variable and the endogenous construct and (b) regression weights of the endogenous construct on the exogenous constructs.

To assess model fit, we reported five indexes. First, we reported the chi-square statistic (χ^2), which tests the null hypothesis that a hypothesized model perfectly reproduces the correlation matrix for the manifest variables. The chi-square statistic is obtained by first computing a discrepancy function, then multiplying it by $N - 1$. The discrepancy function is a measure of how much the correlation matrix from the observed data differs from the "reproduced" correlation matrix generated by the model and the maximum likelihood estimates of its parameters. For a given sample size, the larger the chi-square, the more the correlation matrix generated by the hypothesized model deviates from the correlation matrix for the manifest variables. However, since models seldom if ever fit perfectly in either the population or the sample, even models that fit very well may yield statistically significant chi-square statistics when sample sizes are large (Bentler, 1990).

Second, we reported the Adjusted Population Gamma Index (APGI), which provides a direct measure of goodness-of-fit. This index (Steiger, 1989, 1995) is an estimate of the population equivalent of the Adjusted Goodness of Fit Index (AGFI) proposed by Jöreskog and Sörbom (1984). As a measure of fit, the AGFI has much to recommend it. However, as demonstrated independently by Steiger (1989) and Maiti and Mukherjee (1990), the AGFI is a negatively biased estimator of the corresponding population quantity. Consequently, the AGFI provides a somewhat pessimistic index of the actual quality of model fit in the population. The APGI we reported here may be regarded as a bias-corrected version of the AGFI. Values above .90 conventionally indicate a good fit.

Third, we reported the Comparative Fitness Index (CFI), which is a normed-fit index that evaluates the adequacy of the hypothesized model in relation to a baseline model (Bentler, 1990). CFI is computed on the basis of the most restricted baseline model (null model) in which all manifest variables are assumed to be uncorrelated (i.e., every variable is an indicator for its own latent construct). Possible values range from 0 to 1, with higher values indicating better fit. Values above .90 conventionally indicate a good fit.

Fourth, we reported Steiger and Lind's (1980) RMSEA, which can be regarded as a root mean square standardized residual. RMSEA uses an estimate of the population discrepancy function, adjusted for model complexity, and is therefore useful in both evaluating the degree of model fit and comparing two nested models. Greater values indicate poorer fit. Values lower than .08 conventionally indicate a good fit. However, in RMSEA, fit is affected by the maximum likelihood discrepancy function, which is asymptotically equivalent to a "weighted" function of the sum of squared differences between observed and reproduced correlation matrices. The weights are inversely related to the variances of the parameter estimates. When variables are very highly correlated, these weights can become quite large, in which case the RMSEA can become inflated even when the model reproduces the correlation matrix well (Steiger, 2000). Other authors have also discussed this phenomenon (Browne, MacCallum, Kim, Andersen, & Glaser, 2002; Saris, Satorra, & van der Veld, 2009).

Fifth, when the focus was on a specific endogenous variable, we reported variance accounted for (VAF), which is the percentage of variance in the endogenous variable explained by the exogenous variables.

RANDALL. Tracey's (1997) RANDALL provides a Correspondence Index (CI), which is a correlation coefficient that indicates the extent to which the model predictions of hypothesized order relations are met in the sample data. The CI ranges from 1.00 (every prediction met) to −1.00 (every prediction violated), with 0.00 indicating that an equal number of predictions have been met and violated. Rounds and Tracey (1996) found a benchmark CI value of .70 in their meta-analysis of U.S. samples and measures and this value is therefore conventionally taken to indicate a good fit. This test also provides a p value that indicates the proportion of hypothesized predictions met or exceeded in the set of 1,000 permutations of the rows and columns of the sample correlation matrix.

CIRCUM. For CIRCUM (Browne, 1992) analysis, nonipsative data were used. In all models, the communality estimates of all variables were left free to vary. No constraints were put on the minimum common score correlation (MCSC). CIRCUM estimates the angle, θ (theta), on the circle for each variable, as well as a 95% confidence interval for that angle. It also provides ζ (zeta), which is a communality index, the square root of the proportion of variance of each variable explained by the CIRCUM model. To assess model fit, we reported χ^2 and RMSEA.

Controlling Systematic Error

There has been a long history of research showing that mood and emotion scales are subject to an acquiescence bias (i.e., individual differences in use of the response scale irrespective of content; Bentler, 1969; Russell, 1979). A principal components analysis of the 42 × 42 correlation matrix for the mood scales (14 scales × 3 response formats) showed evidence for such a bias in our data. The first two principal components (with eigenvalues of 17.53 and 12.22) accounted for 77.3% of the total variance. In the unrotated solution, Factor 1 was interpretable as Pleasure versus Displeasure, and Factor 2 as Activation versus Deactivation. There was also a third principal component (with eigenvalue of 2.72) that was a general factor with positive loadings from all 42 scales. Because this factor represented response differences irrespective of content, including scales of opposite content, we interpreted this third factor as consistent with an acquiescence bias. To reduce this general factor, wherever possible, subsequent analyses were based on ipsative data.[1] Ipsative data are likely inappropriate for CIRCUM analyses (M. Browne, personal communication, September 12, 2002), and we therefore used the nonipsative data for CIRCUM.

Acquiescence is not the only potential systematic error in the ratings. In the structural equation models used in the subsequent analyses, correlating error terms can remove some of this remaining systematic error. Even with ipsative data, correlating error terms did indeed generally improve fit—even when the fit was indexed by RMSEA, which penalizes lack of parsimony. On the other hand, the three response formats used here resembled one another and therefore the method of correlating error terms cannot remove all systematic error.

Results

Four Separate Structural Models

Results from separate confirmatory factor analyses for each of the four models are given in Table 2. With the exception of Watson and Tellegen's (1985) model, all hypothesized models fit the data. Comparison models with the major constructs uncorrelated fared worse than the hypothesized models; again with the exception of Watson and Tellegen's model. These results provide initial support for the structural models proposed by the original authors. Individual constructs were adequately measured by the scales. Constructs within the structure were related to each other approximately as predicted. For example, in Barrett and Russell's (1998) model, the variables purported to represent opposite ends of a bipolar continuum showed the expected correlations: correlation between Pleasure and Displeasure was –.90 and that between Activation and Deactivation was –.90. Nevertheless, these results also point to other questions: If each model is supported when examined alone, which one should be used to describe momentary feelings? And, can they be integrated to capture what they have in common? To answer these questions, we examine the relations among the four structural models.

Integration of Four Structural Models

How can the four models of Table 2 be integrated? Integration requires that all 14 affect constructs fit within the same two-

[1] Ipsatization removes individual differences in grand mean and variance. For instance, to ipsatize the Pleasant ADJECTIVE score, we deduct an individual's grand mean of ADJECTIVE scales from that individual's Pleasant ADJECTIVE score; this difference is divided by the standard deviation of the ADJECTIVE scale scores for the same individual. Ipsatization for this purpose requires that the scales be heterogeneous in content, ideally including opposite content. (e.g., if the ADJECTIVE scale of "Pleasant" is in the pool, then its theoretical semantic opposite, the ADJECTIVE scale of "Unpleasant," would have to be there as well.) This consideration led us to use 12 rather than the full 14 scales in each response format. (Watson and Tellegen's Positive Activation and Negative Activation were excluded because they lacked semantic opposites.) We ipsatized our data across the 12 scales within each response format. In total, we created 36 ipsative scores, 12 within each response format. With the ipsative data, we computed a 36 × 36 correlation matrix and submitted it to an exploratory factor analysis. The three eigenvalues were 13.95, 11.42, and 1.96. The third factor was no longer a general factor. It yielded 17 positive loadings and 19 negative loadings from the 36 scales. Indeed, it was difficult to interpret. We repeated this series of analyses with data from the 12 affect segments in each of Studies 1 to 4. Similar results were obtained in each case.

Table 2
*Confirmatory Factor Analyses: Indexes of Fit for the Four Structural Models in Study 1 (*N *= 535)*

Model	χ^2	*df*	RMSEA	APGI	CFI
Barrett & Russell's (1998) Constructs					
Hypothesized model	160.63	30	.09	.90	.98
Comparison model	1433.89	36	.21	.54	.76
Larsen & Diener's (1992) Constructs					
Hypothesized model	139.24	30	.08	.92	.98
Comparison model	1353.25	36	.22	.52	.79
Thayer's (1996) Constructs					
Hypothesized model	147.50	30	.08	.91	.98
Comparison model	1543.12	36	.21	.56	.78
Watson & Tellegen's (1985) Constructs					
Hypothesized model	145.13	5	.23	.67	.96
Comparison model	247.22	6	.25	.61	.93

Note. Hypothesized model = Model with correlations between constructs estimated; Comparison model = Model with correlations between constructs fixed to zero; RMSEA = Root mean square error of approximation; APGI = Adjusted population gamma index; CFI = Comparative fit index.

dimensional space. As mentioned, two principal components of the 42 individual scales (14 × 3 scales) accounted for 77.3% of the total variance. When 14 scales were formed by summing across three scales in different response formats, with ipsative data, two principal components accounted for 80.0% of the total variance. The angular positions of the 14 constructs within the two-dimensional space created by the two principal components are given in the second to last column of Table 3. These results show that the 14 constructs of the four models share a large amount of variance. They fit well within a two-dimensional space approximately in the way anticipated.

The next question is whether various mood dimensions can be accounted for by two specific axes: valence (Pleasure vs. Displeasure) and arousal (Activation vs. Deactivation). This question can be examined by treating the two axes as exogenous variables used to predict each of the other constructs, treated as endogenous. Thus, a measurement model for the two exogenous constructs was created first. Because the valence axis was shown to be bipolar in the analyses already reported, it was indicated by six scales (i.e., three Pleasure scales in different response formats and three Displeasure scales in different response formats). Similarly, the arousal axis was indicated by six scales. The semantic differential scale of pleasure was specified to load on the valence construct; the semantic differential scale of arousal was specified to load on the arousal construct. The correlation between the two latent constructs was fixed to .00. The fit indexes were $\chi^2(16, N = 535) = 125.36$, RMSEA = .11, APGI = .90, and CFI = .97. Altogether, the fit indexes indicate good fit, although, as antici-

Table 3
*Structural Equation Models: Predicting 10 Mood Constructs From the Bipolar Axes in Study 1 (*N *= 535)*

	Structural equation model[a]				PCA[b]	CIRCUM
	Regression weights					
Mood construct	Pleasure	Arousal	VAF (SE)	Angle	Angle	Angle
Pleasant				—	0°	0°
Larsen & Diener's (1992) Activated Pleasant	.69	.50	72 (2.4)	36°	33°	42°
Watson & Tellegen's (1985) Positive Affect	.69	.55	75 (2.2)	39°	38°	47°
Thayer's (1996) Energy	.48	.77	82 (1.9)	58°	53°	59°
Activated				—	90°	89°
Thayer's (1996) Tension	−.62	.58	72 (2.3)	137°	145°	131°
Larsen & Diener's (1992) Activated Unpleasant	−.80	.39	78 (2.1)	154°	159°	145°
Watson & Tellegen's (1985) Negative Affect	−.82	.25	73 (2.1)	163°	162°	151°
Unpleasant				—	181°	179°
Larsen & Diener's (1992) Unactivated Unpleasant	−.46	−.68	67 (2.8)	236°	235°	240°
Thayer's (1996) Tiredness	−.31	−.66	53 (3.2)	245°	240°	242°
Deactivated				—	267°	269°
Thayer's (1996) Calmness	.57	−.67	77 (2.3)	310°	312°	300°
Larsen & Diener's (1992) Unactivated Pleasant	.69	−.47	70 (2.3)	326°	325°	311°

[a] *df* for $\chi^2 = 58$. All regression weights are significant at .001 level. VAF = Variance accounted for, in %; *SE* = standard error. Each angle was computed using the regression weights resulting from a structural equation model. [b] Each angle was computed using the factor loadings obtained in a principal components analysis of 14 affect constructs.

pated, χ^2 was significant, presumably because of our large sample size, and RMSEA was higher than the conventional standard, presumably because of the high correlations in the matrix of manifest variables. Parameter estimates from this model were used in defining the parameters on the exogenous side of the structural equation models reported next.

A separate structural equation model was tested for each of the remaining 10 constructs from the three models. Values of RMSEA ranged from .07 to .10; values of APGI ranged from .88 to .93; values of CFI ranged from .95 to .97. The variance explained ranged from 53% to 82%, with a mean of 72%. (Results were similar to those reported by Yik et al. [1999] in which variance explained ranged from 53% to 90%, with a mean of 72%.) The mean variance explained was similar for three quadrants—76% for the pleasant activated states, 74% for the unpleasant activated states, and 74% for the pleasant deactivated states—but lower for the fourth—60% for the unpleasant deactivated states. Further, the regression weights conformed to the expected pattern in all cases. This analysis provided another estimate of the angular position for each of the 10 constructs. These results are summarized in Table 3. The results are strikingly similar to those estimated by the principal components analysis. The major requirement for integration was fulfilled in the finding that every construct could be substantially explained by the two bipolar axes interpretable as valence and arousal.

Placement of 14 Constructs in One Space

Our next question was the precise placement of each of the 14 constructs within the common two-dimensional space. Do separate constructs fall 45° apart or some multiple of 45°? This proposal has been phrased as the 45°-rotation hypothesis, because it implies that all four models are equivalent once some of them are rotated 45°. For this purpose, we used CIRCUM, because it provides not only an angle within a circular ordering but also a confidence interval for that angle. Separate analyses for the 14 scales within each response format yielded extremely similar results, and we therefore created a combined score for each of the 14 constructs by summing the z-scores of its three separate scales with different formats. (The semantic differential scale was not used in this analysis.) Pleasant was designated as the reference variable (its location was fixed at 0°), relative to which the locations of other variables were estimated. The analysis converged on a solution in 17 iterations. Three free parameters were specified in the correlation function equation; additional free parameters did not improve the model fit. The final model had a total of 44 free parameters and 61 degrees of freedom. The fit indexes for the model were $\chi^2(61, N = 535) = 506.23$, RMSEA = .12, and MCSC = –.82. Values of ζ ranged from .90 to 1.00.

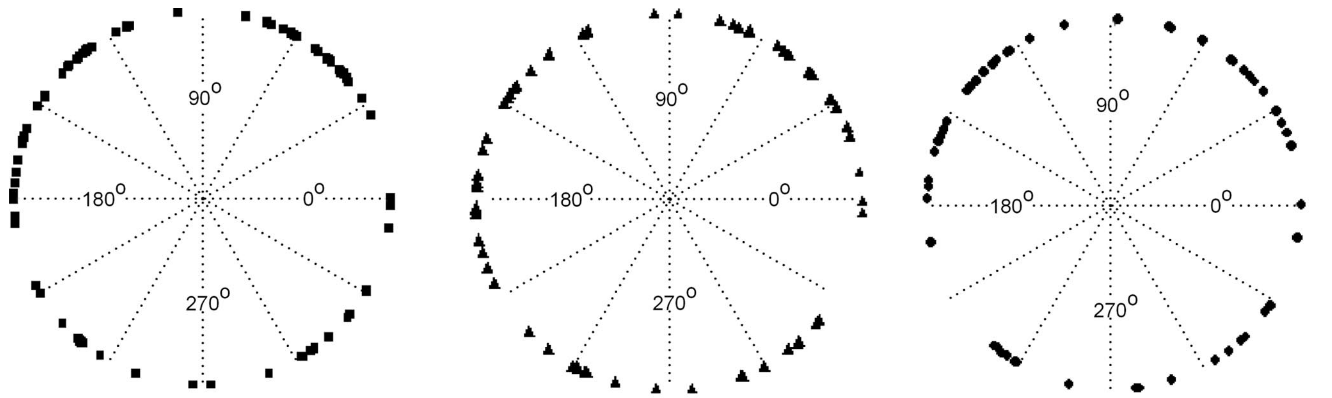
The placement of the 14 constructs is given in the last column of Table 3 and is shown in the outer circle of Figure 2. The four cornerstone variables (Pleasant, Unpleasant, Activated, and Deactivated) were located close to the predicted values: With Pleasant fixed at 0°, Activated was 89° away, Unpleasant was 179° away, and Deactivated was 269° away. Hypothesized bipolar opposites were located close to the predicted values: Pleasant was 179° from its bipolar opposite, Unpleasant. Activated was 180° from its bipolar opposite, Deactivated. The remaining 10 constructs fell into the predicted quadrant. Thus CIRCUM confirmed all 14 constructs from the four models fell in a meaningful pattern within a two-dimensional space. The rank order of the 14 constructs as one moves about the perimeter of that space was identical in CIRCUM, the principal components analysis, and the structural equation models.

CIRCUM's ability to provide precise angles, however, cautions against two related assumptions about integration. First, as shown in Figure 2, the 14 constructs were not equally spaced around the perimeter of the space. And, second, scales that, according to the 45°-rotation hypothesis, would be identical differed by anywhere up to 20° from each other. No large differences occurred in the unpleasant deactivated quadrant, but noticeable differences did occur within the other three. The confidence interval for Thayer's (1996) Energetic Arousal did not overlap with the confidence intervals of Larsen and Diener's (1992) Activated Pleasant or Watson and Tellegen's (1985) Positive Activation. The confidence interval for Thayer's Tense Arousal did not overlap with the confidence intervals of Larsen and Diener's Activated Unpleasant or Watson and Tellegen's Negative Activation. The confidence interval for Thayer's Calmness did not overlap with the confidence interval of Larsen and Diener's Unactivated Pleasant. Although these differences were small, they were reliable. First, the confidence intervals estimated by CIRCUM showed that the reported angles are quite precise. Second, similar differences between these scales were found by Yik et al. (1999). Equal spacing and the 45°-rotation hypothesis are therefore but rough approximations. Variables fell at various angles within the space of Figure 2, not only at multiples of 45°. This result challenges the goal of simple structure, but is consistent with a circumplex approach, which allows variables to fall at any place along a circle.

In summary, these results show that constructs defined by different structural models of momentary feelings are highly related to one another and therefore can be well represented by an integrated structure. On the other hand, no measured variable was completely accounted for by the two-dimensional integrated structure. On our interpretation, what the 14 constructs have in common, what the structure of Figure 2 represents, is Core Affect. The underlying bipolar axes are interpretable as the valence and the arousal dimensions. The 14 measured variables are largely but not entirely a combination of these two axes.

Despite the reliable differences observed, the reader might well look at Figure 2 and see a reasonable approximation to the simple integration we dubbed the 45°-rotation hypothesis. Figure 2 shows how *preexisting scales* fall in a common two-dimensional space—scales designed to fall 45° apart. It is interesting to examine how individual *items* fall in the same space. We therefore placed all items into a two-dimensional space. For each response format, we created a circular ordering of the items by following an approximation procedure specified by Browne (1992, Formula 48).[2] This procedure estimates the angular position for each item. Results are summarized in Figures 3A to 3C. Even though derived from scales

[2] The procedure we followed is only an approximation to the analysis produced by CIRCUM (Browne, 1992). Michael Browne kindly provided us with instructions on how to create a circular ordering of items or scales using confirmatory factor analysis. The major difference between our approximation procedure and CIRCUM procedures lies in the number of free parameters in the Fourier correlation function and in the estimation of communality: the approximation procedure assumes 1 free parameter in the Fourier correlation function and equal communality of the variables. CIRCUM, on the other hand, allows us to vary the number of free parameters in the Fourier correlation function and to estimate communality of the variables.



A. 75 items of the ADJECTIVE format. B. 61 items of the AGREE format. C. 55 items of the DESCRIBE format.

Figure 3. A circumplex analysis of individual Core Affect items (Study 1, $N = 535$).

aimed at 45° differences, items clearly did not cluster at multiples of 45° and did not show simple structure. Rather, they fell at various angles throughout the two-dimensional space. Put differently, simple structure and the 45°-rotation hypothesis predict systematic gaps spaced 45° apart in the graphs of Figure 3; those much needed gaps were not systematic and did not replicate across response formats.

Creation of a 12-Point Circumplex

Creation of 12 segments. Analyses at both the scale level and the item level indicated that slicing the two-dimensional space into multiples of 45° is an arbitrary decision. We next examined the viability of yet another arbitrary decision—slicing the space into 12 segments approximately 30° apart. Our target structure is shown in Figure 1. We used the data of Study 1 to (a) create a 12-point circumplex of Core Affect and (b) develop scales for the resulting 12 segments. The metaphor of a clock provides names for the segments: I through XII. We constructed scales in three different formats, for a total of 36 scales.

A separate analysis was conducted for each response format. Based on the item-level analyses shown in Figure 3, we grouped the items into 12 clusters, each roughly 30° apart. The process was simultaneously rational (based on the names given in Figure 1), empirical (based on each item's reliability and position in the analyses of Figure 3), and practical (aimed at roughly equal number of items in each segment). In this process, we dropped 31 of the total 191 items. (This left 60 ADJECTIVE items, 52 AGREE items, and 48 DESCRIBE items in the 36 scales.) We kept the original items of the Pleasant and Unpleasant scales.[3] The remaining segments were created without respect to the structural model or scale from which they originated. Items are given in the Appendix.

The clusters of items in Table A1 show the pattern that quickly emerged. We found it harder to find items for Segments III, VI, IX, and XII than for the others—that is, items that convey pure pleasure or displeasure with no hint of the accompanying level of arousal or items that convey pure activation or deactivation with no hint of the accompanying valence. As Osgood (1966) showed, words tend to convey *both* valence and activation.

Items that fell off the main axes provided a distinction that allowed our conceptual change from eight segments to 12. For example, consider the pleasant activated quadrant. Some words and phrases denote primarily a highly pleasant state with a secondary implication of accompanying arousal (e.g., *elated* and *enthusiastic*). In contrast, other words and phrases from this same quadrant denote primarily high activation with the secondary implication of positive valence (e.g., *energetic* and *activated*). This subtle distinction allowed the differentiation of Segment I from Segment II. A similar pattern occurred in each quadrant. Thus, although the scales in Table A1 are but a first step, they emerged in a way that clarifies the meaning of words and phrases descriptive of Core Affect and that provides a rationale for further development of its structure and for scales to tap that structure.

Variance explained by the revised axes. In a structural equation model similar to that described earlier, the bipolar valence axis and the bipolar (slightly revised) arousal axis served as exogenous variables to predict each of the other eight segments of the 12-PAC. The fit indexes were $\chi^2(16, N = 535) = 107.15$, RMSEA = .10, APGI = .91, and CFI = .98. Parameter estimates from this model were used in defining the parameters on the exogenous side of eight separate structural equation models, one for each of the remaining constructs within the 12-PAC. Results are summarized in Tables 4 and 5 (Study 1 Yesterday), and were also similar to those of the preceding section. All segments could be substantially explained by the two axes: The variance explained ranged from 55% to 86%, with a mean of 76%. Further, the pattern of relations between the exogenous and endogenous constructs was as expected in Figure 1.

A circular ordering of the 12 segments. For scales of a common response format, we first applied CIRCUM, followed by RANDALL analysis. The fit indexes for the ADJECTIVE format were $\chi^2(40, N = 535) = 297.44$, RMSEA = .11, MCSC = –.71, CI = .88, and p value = .001. The fit indexes for the AGREE

[3] We examined the slightly revised scales for the axes. The fit indexes were $\chi^2(30, N = 535) = 192.33$, RMSEA = .10, APGI = .88, and CFI = .97. The correlation between Pleasant and Unpleasant was –.92 and that between Activated and Deactivated was –.88.

Table 4
Structural Equation Models: Indexes of Fit for the Ability of the Bipolar Axes to Predict the Remaining Segments of the 12-PAC

Segment	Study	χ^2 1 Y	χ^2 2	χ^2 3	χ^2 4 Y	χ^2 4 LS	RMSEA 1 Y	RMSEA 2	RMSEA 3	RMSEA 4 Y	RMSEA 4 LS	APGI 1 Y	APGI 2	APGI 3	APGI 4 Y	APGI 4 LS	CFI 1 Y	CFI 2	CFI 3	CFI 4 Y	CFI 4 LS
II	Activated Pleasure (30°)	296.28	137.18	180.96	223.26	267.06	.09	.08	.09	.08	.09	.92	.92	.91	.93	.90	.96	.96	.96	.97	.96
I	Pleasant Activation (60°)	263.85	172.21	170.56	269.96	222.20	.08	.09	.09	.09	.08	.93	.91	.92	.91	.93	.97	.95	.96	.96	.97
XI	Unpleasant Activation (120°)	300.41	136.62	250.26	288.51	345.37	.09	.09	.12	.10	.12	.92	.92	.85	.89	.86	.96	.96	.93	.95	.93
X	Activated Displeasure (150°)	307.51	169.47	163.85	295.07	328.94	.09	.09	.09	.10	.11	.92	.90	.92	.89	.88	.96	.94	.96	.95	.94
VIII	Deactivated Displeasure (210°)	210.19	136.31	198.65	240.30	230.47	.07	.09	.11	.09	.09	.94	.92	.88	.91	.92	.97	.96	.95	.96	.96
VII	Unpleasant Deactivation (240°)	329.65	171.88	177.23	209.12	199.15	.09	.10	.09	.08	.08	.91	.90	.91	.93	.94	.96	.95	.96	.97	.97
V	Pleasant Deactivation (300°)	218.89	144.76	192.51	368.95	281.94	.07	.09	.10	.12	.10	.94	.92	.90	.86	.89	.97	.95	.95	.93	.95
IV	Deactivated Pleasure (330°)	276.30	150.20	172.23	263.88	279.42	.08	.09	.09	.09	.10	.92	.91	.91	.90	.90	.96	.95	.96	.96	.95

Note. Study 1 (N = 535); Study 2 (N = 190); Study 3 (N = 234); Study 4 (N = 395). Y = Yesterday moment; LS = Last Saturday moment. *df* for each structural equation model = 58. RMSEA = Root mean square error of approximation; APGI = Adjusted population gamma index; CFI = Comparative fit index.

Table 5
Structural Equation Models: Predicting Eight Segments From the Bipolar Axes

Segment	Study	Regression weight: Pleasure 1 Y	Pleasure 2	Pleasure 3	Pleasure 4 Y	Pleasure 4 LS	Arousal 1 Y	Arousal 2	Arousal 3	Arousal 4 Y	Arousal 4 LS	VAF (SE) 1 Y	VAF (SE) 2	VAF (SE) 3	VAF (SE) 4 Y	VAF (SE) 4 LS
II	Activated Pleasure (30°)	.83	.84	.87	.82	.83	.36	.36	.39	.43	.42	82 (1.8)	84 (3.1)	90 (2.3)	86 (1.7)	86 (1.7)
I	Pleasant Activation (60°)	.53	.42	.48	.48	.54	.72	.81	.80	.81	.74	79 (2.0)	84 (3.2)	88 (2.2)	89 (1.5)	84 (1.9)
XI	Unpleasant Activation (120°)	−.50	−.52	−.59	−.60	−.62	.62	.63	.67	.61	.59	64 (2.8)	67 (4.7)	80 (2.9)	74 (2.6)	73 (2.8)
X	Activated Displeasure (150°)	−.88	−.93	−.90	−.86	−.93	.29	.27	.31	.29	.19	86 (1.6)	94 (2.6)	91 (2.1)	83 (2.0)	90 (1.6)
VIII	Deactivated Displeasure (210°)	−.87	−.89	−.87	−.88	−.91	−.22	−.17	−.20	−.23	−.17	80 (2.2)	82 (3.6)	79 (2.9)	83 (1.9)	85 (1.9)
VII	Unpleasant Deactivation (240°)	−.36	−.37	−.43	−.39	−.41	−.65	−.74	−.72	−.76	−.73	55 (3.0)	69 (4.3)	69 (3.6)	73 (2.4)	70 (2.7)
V	Pleasant Deactivation (300°)	.62	.65	.67	.64	.69	−.69	−.63	−.66	−.69	−.61	86 (1.8)	81 (3.6)	89 (2.2)	88 (1.9)	84 (2.2)
IV	Deactivated Pleasure (330°)	.79	.80	.84	.83	.83	−.39	−.34	−.39	−.39	−.30	78 (2.3)	76 (3.9)	85 (2.5)	83 (2.0)	78 (2.3)

Note. Study 1 (N = 535); Study 2 (N = 190); Study 3 (N = 234); Study 4 (N = 395). Y = Yesterday moment; LS = Last Saturday moment. VAF = Variance accounted for, in %; *SE* = Standard error. df for each structural equation model = 58. All regression weights are significant at .001 level.

format were $\chi^2(40, N = 535) = 391.42$, RMSEA = .13, MCSC = –.82, CI = .90, and p value = .001. The fit indexes for the DESCRIBE format were $\chi^2(40, N = 535) = 280.35$, RMSEA = .11, MCSC = –.83, CI = .88, and p value = .001. As in previous analyses, the fit indexes were adequate, with RMSEA showing the anticipated values higher than conventionally seen. These individual analyses yielded extremely similar results and demonstrated strong validation of the structure across response formats.

Studies 2–4: Cross-Validation and Placing External Variables Within the 12-PAC

We next report three additional studies, each with a similar purpose. Each was aimed at cross-validating the 36 newly created scales and the 12-PAC structure, with data gathered with different samples and somewhat different methods. In Study 2, participants reported their Core Affect at a current moment while they were outside the laboratory. In Study 3, we turned to the more standard method of bringing participants into a laboratory and asking them to describe their current Core Affect. In Study 4, we returned to the use of remembered moments, once from yesterday and once, for the same participants, from the previous Saturday.

In Study 3, we also examined the relationship between Core Affect and current mood. We placed 20 commonly used mood scales within the 12-PAC. All mood scales began with instructions asking the participants to describe how they felt “right now.” Although “mood” and Core Affect are somewhat different concepts, we anticipated a substantial association between them on the hypothesis that Core Affect is the major component of mood. In this study, we used the cosine wave technique and the CIRCUM-extension procedure (M. Browne, personal communication, June 12, 1999).

In both Studies 3 and 4, we sought to place various personality scales within the 12-PAC. Although Core Affect and personality are different concepts, we believe that personality can predict the Core Affect of the moment (e.g., Yik, 2010; Yik & Russell, 2001). As well, personality correlates have been used to argue for the proper rotation of the axes of the Core Affect space (Watson et al., 1999). Study 3 had found, not surprisingly, that the correlation between Core Affect and a personality scale tended to be low. One reason is that we had sampled but a single slice in time for Core Affect, and feelings at a slice in time are determined not only by personality but by current circumstances. To provide a more stable estimate of the Core Affect-trait relation, we asked the participants in Study 4 to report how they had felt during two separate remembered moments, one from yesterday (which could have been any day of the week except Friday or Saturday) and the other moment from the previous Saturday.

Method

Participants

In all three studies, participants were university undergraduates. In Study 2, $N = 190$ (63 men and 127 women); in Study 3, $N = 234$ (77 men and 157 women); and in Study 4, $N = 395$ (144 men and 251 women).

Procedures

In Study 2, participants were given a questionnaire to take home with them. Because a person is always in some state of Core Affect, we sought to sample a reasonably wide range of times of day. Participants were randomly assigned to one of six conditions, each of which specified a time (before breakfast, after breakfast, before lunch, after lunch, before dinner, and after dinner) for completing the questionnaire on a day of their choice over the following three days. When the participants sat down to complete the questionnaire, they found instructions asking them to begin by contemplating their feelings at *that moment* and then to fill out the questionnaire with regard to *that moment*. Participants were to consider the current moment even if it was not at the preassigned time. They were explicitly asked to use the questionnaire to describe their feelings at that moment rather than to describe feelings as they changed over the course of completing the questionnaire. They returned the questionnaires to a research lab upon completion.

In Study 3, participants completed two batteries of questionnaires during a 1-hr laboratory session. Laboratory sessions were held at three prescribed times throughout a day, namely, 9 a.m. to 10 a.m., 1 p.m. to 2 p.m., and 5 p.m. to 6 p.m. The first battery concerned mood and Core Affect, the second personality.

In Study 4, participants completed three batteries of questionnaires during a 1-hr laboratory session. The first two batteries included the 12-PAC scales, with instructions identical to those used in Study 1, except that each concerned a different moment—one from the previous day (Study 4 Yesterday) and the other from the previous Saturday (Study 4 Last Saturday). For each moment, participants were randomly assigned to one of six versions (before breakfast, after breakfast, before lunch, after lunch, before dinner, and after dinner). Half of the participants completed the battery about Yesterday first and the remaining half completed the one for Last Saturday first. The third battery was a personality packet.

Core Affect and Mood Measures

In all three studies, the questionnaires concerning momentary feelings were titled “Mood Scales.” The 12-PAC scales provided in the Appendix were used as the measure of Core Affect. To represent areas within the affect space that were underrepresented, 9 items were added. There were altogether 60 ADJECTIVE items, 57 AGREE items, and 52 DESCRIBE items. Instructions were identical to those used in Study 1.

In Study 3, the “Mood Scales” questionnaires also included the following additional measures:

Positive Affect and Negative Affect Schedule Expanded. Watson et al.’s (1988) scales was embedded within the ADJECTIVE format. Thus, in Study 3, the ADJECTIVE questionnaire consisted of 96 items.

Semantic differential scales. We used the state version of Mehrabian and Russell’s (1974) semantic differential scales of Pleasure, Arousal, and Dominance. Each scale consists of six bipolar pairs of adjectives in semantic differential format.

Affect Grid Scales. We modified the Affect Grid (Russell, Weiss, & Mendelsohn, 1989) by converting it into two bipolar rating scales, one on “Extremely Unpleasant versus Extremely Pleasant” and another on “Extremely Sleepy versus Extremely Aroused.” In each item, participants were to indicate their current mood state by choosing one of the nine boxes located between each pair of polar opposites.

Implicit Positive and Negative Affect Test. We included the Implicit Positive and Negative Affect Test, a recently developed measure that was shown to be more sensitive than self-report mood scales to subtle mood changes in experimental inductions (Quirin et al., 2009). Participants were asked to rate the extent each of six artificial words (SAFME, VIKES, TUNBA, TALEP, BELNI, SUKOV) "sounds like" each of eight preselected mood adjectives using a four-point rating scale ranging from 1 (*doesn't fit at all*) to 4 (*fits very well*). For the mood adjectives, we used the ADJECTIVE items defining Pleasure (*happy, pleased, satisfied, content*) and Displeasure (*troubled, unhappy, miserable, dissatisfied*). Each artificial word was paired with eight ADJECTIVE items, resulting in 48 ratings (six artificial words × eight adjectives). Score for Implicit Pleasure was computed by averaging all 24 ratings about the fitness between the six artificial words and the four Pleasure items. Score for Implicit Displeasure was computed by averaging all 24 ratings about the fitness between the six artificial words and the four Displeasure items.

Personality Trait Measures in Study 3

In Studies 3 and 4, we included a packet of personality scales. The front page of the personality packet provided the instruction to ". . . describe yourself as you are GENERALLY and TYPICALLY." In Study 3, participants completed five personality inventories in the following order.

Behavioral Inhibition and Activation Scales. Carver and White's (1994) 20-item inventory was used to measure Behavioral Activation System and Behavioral Inhibition System. Behavioral activation was tapped by three subscales—reward responsiveness, drive, and fun seeking—which were also scored separately. Biological evidence for these two measures was provided by Sutton and Davidson (1997). Thirteen items are used to measure the behavioral activation system and 7 items to measure the behavioral inhibition system. Responses are made on a 4-point rating scale, ranging from 1 (*strongly disagree*) to 4 (*strongly agree*).

Big Five Mini-Markers. Saucier (1994) derived 40 unipolar markers, on the basis of reanalyses of 12 data sets, to measure the Five Factor Model of personality (Costa & McCrae, 1992)—Emotional Stability, Extraversion, Intellect, Agreeableness, and Conscientiousness. The 40 markers, eight for each personality dimension, were a subset of Goldberg's (1992) 100 adjectives. Participants were asked to indicate how accurately each adjective describes themselves on a 9-point rating scale, ranging from 1 (*extremely inaccurate*) through 5 (*neutral*) to 9 (*extremely accurate*). Each personality trait score was the mean of its eight constituent items.

Life Orientation Test. The 12-item scale was developed to assess individual differences in generalized optimism for the future (Scheier & Carver, 1992). Participants were asked to indicate their agreement to each item using a 5-point rating scale, ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). There were four filler items. The scale score was the mean of the remaining eight items.

Beck Depression Inventory. The inventory measures characteristic attitudes and symptoms of depression, including sadness, pessimism, sense of failure, social withdrawal, and insomnia (Beck, 1967). There are 21 groups of four statements and each statement is assigned one score (0, 1, 2, or 3). Participants were asked to choose one statement that best described how they were feeling in the "past week, including today." The scale score was the mean of all 21 ratings.

Trait-Anxiety Scale. We included the trait version of Spielberger's (1983) State-Trait-Anxiety scale, which assesses individual differences in anxiety proneness. It consists of 20 items measuring how participants "generally feel" on a 4-point rating scale, ranging from 1 (*almost never*) to 4 (*almost always*). A trait-anxiety score was the mean of 20 items, 7 of which were reverse-scored.

Personality Trait Measures in Study 4

With the same general instructions used in Study 3, participants in Study 4 completed six personality inventories in the following order.

Semantic differential scales. We used the trait version of Mehrabian and Russell's (1974) semantic differential scales of Pleasure, Arousal, and Dominance.

NEO Five Factor Inventory. The NEO Five Factor Inventory is a 60-item questionnaire designed to measure the Five Factor Model of personality (Costa & McCrae, 1992)—Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness. Each factor is represented by 12 items. Responses are made on a 5-point rating scale ranging from 1 (*strongly disagree*) through 3 (*neutral*) to 5 (*strongly agree*).

Positive Affect and Negative Affect Schedule. The "in-general" version of the 20-item scale (Watson et al., 1988) was used to measure trait versions of Positive Affect and Negative Affect. Each construct is represented by 10 items. Responses are made on a 5-point rating scale ranging from 1 (*very slightly*) to 5 (*extremely*).

Eysenck Personality Questionnaire. The Neuroticism and Extraversion subscales of the Eysenck Personality Questionnaire (Eysenck & Eysenck, 1975) consisting of 44 items were administered to the sample. Responses were made on "Yes-No" scale.

Behavioral Inhibition and Activation Scales. Carver and White's (1994) 20-item inventory used in Study 3 was also included in Study 4.

Interpersonal Adjective Scales Revised. Wiggins, Trapnell, and Phillips' (1988) 64-item scale consists of eight octants of traits, each defined by eight adjectives: Assured-Dominance (PA), Arrogant-Calculating (BC), Cold-hearted (DE), Aloof-Introverted (FG), Unassured-Submissive (HI), Unassuming-Ingenuous (JK), Warm-Agreeable (LM), and Gregarious-Extraverted (NO). Participants were presented with a list of single adjectives and asked to rate the self-descriptive accuracy of each adjective on an 8-point rating scale ranging from 1 (*extremely inaccurate*) to 8 (*extremely accurate*). Each octant score was the mean of its eight constituent items.

Data Analysis

We followed the analysis sequence in Study 1.

Results

Cross-Validation of the 12-PAC Structure

Descriptive statistics and alpha coefficients for the 36 12-PAC scales are given in Table A2. Alphas ranged from .64 to .93 (Study 2),

.70 to .93 (Study 3), and .71 to .94 (Study 4) for the ADJECTIVE format; from .75 to .94 (Study 2), .75 to .94 (Study 3) and .77 to .95 (Study 4) for the AGREE format; and from .75 to .92 (Study 2), .79 to .93 (Study 3), and .73 to .95 (Study 4) for the DESCRIBE format.

To examine the four cornerstone constructs of the two-dimensional space, we specified a confirmatory factor analysis with four latent variables (Pleasant, Unpleasant, Activated, and Deactivated), each indicated by its three corresponding scales with different response formats. As shown in Table 6, the hypothesized model replicated well. The estimated correlation between Pleasant and Unpleasant was –.87 (Study 2), –.91 (Study 3), –.93 (Study 4 Yesterday), and –.94 (Study 4 Last Saturday). The estimated correlation between Activated and Deactivated was –.84 (Study 2), –.88 (Study 3), –.88 (Study 4 Yesterday), and –.87 (Study 4 Last Saturday).

The results just described justified creating two bipolar axes: pleasure and arousal. We then used the two bipolar axes as exogenous variables to predict each of the remaining eight segments of the 12-PAC. Results for the eight structural equation models are summarized in Tables 4 and 5. All segments could be substantially explained by the two bipolar axes. The mean variance explained was 80% (Study 2), 84% (Study 3), 82% (Study 4 Yesterday), and 81% (Study 4 Last Saturday).

To portray the full circumplex structure, we next applied CIRCUM (Browne, 1992) within each response format. Each CIRCUM analysis was accompanied by a RANDALL analysis (Tracey, 1997). Results are given in Table 7. The mean values of RMSEA were .11 (Study 2), .10 (Study 3), .12 (Study 4 Yesterday), and .13 (Study 4 Last Saturday). The mean values of CI were .89 (Study 2), .90 (Study 3), .86 (Study 4 Yesterday), and .84 (Study 4 Last Saturday). The results mirrored those in Study 1.

The next question is the convergent validity of the scales across response formats. CIRCUM was used to place all 36 scales within the same two-dimensional space. Scales for the same segment but with different response formats clustered closely together on the circumference of the circle, as shown in Table A2. The 36 scales were found to be psychometrically sound and were properly aligned along the circumference of the space. Results were nearly identical to those obtained in Study 1, showing strong cross-validation. Angular placement of the 12 constructs varied with response format and data set, but not greatly. For a specific construct, the range of values was, on average, 22° out of the possible value of 360°; the mean standard deviation for a construct was 6.06°.

Table 6
Confirmatory Factor Analyses: Indexes of Fit for the Pleasure-Arousal Structural Model

Model	χ^2	*df*	RMSEA	APGI	CFI
Study 2					
Hypothesized model	104.70	30	.11	.86	.96
Comparison model	486.65	36	.21	.54	.77
Study 3					
Hypothesized model	115.04	30	.11	.86	.97
Comparison model	737.11	36	.23	.49	.74
Study 4 Yesterday					
Hypothesized model	114.19	30	.08	.92	.98
Comparison model	1294.94	36	.23	.48	.74
Study 4 Last Saturday					
Hypothesized model	114.29	30	.08	.91	.98
Comparison model	1225.63	36	.22	.51	.74

Note. Study 2 (N = 190); Study 3 (N = 234); Study 4 (N = 395). The hypothesized model consists of the four constructs, Pleasure, Displeasure, Activated, and Deactivated. Hypothesized model = Model with correlations between 4 constructs estimated; Comparison model = Model with correlations between 4 constructs fixed to zero. RMSEA = Root mean square error of approximation; APGI = Adjusted population gamma index; CFI = Comparative fit index.

The Cosine Method: Placing External Variables Into the 12-PAC Space[4]

Mood variables. On our account, Core Affect is related to many variables. We explore this account by examining the relationship of the 12-PAC to an external variable (i.e., one not included in the 12-PAC scales). Not all external variables are related to 12-PAC (i.e., Core Affect), but for any external variable that is related, the circumplex provides a powerful prediction: the set of correlations between the 12 Core Affect variables and that external variable forms a cosine curve. Presence of a cosine curve should therefore be a sensitive test of a relation between a circumplex and the external variable (Yik & Russell, 2001, 2004). Our method estimates the magnitude of the relation (using the metric of the correlation coefficient) of the external variable to the entire circumplex and, separately, estimates where within the circumplex the external variable falls. We first examined this method with the 12-PAC measures separately in each response format, but the patterns obtained were highly similar. We therefore created a composite score for each 12-PAC segment by summing the z-scores from its three scales with different response formats.

The results are illustrated in Figure 4 for one external variable: a mood scale of Fear (Watson & Clark, 1994). Each of the 12-PAC segments is represented on the abscissa by its angle derived from CIRCUM. The ordinate is that segment's correlation with Fear. As predicted, Fear correlated with more than one of the 12-PAC variables; in fact, 10 of the 12 correlations were significant. Also as predicted, the pattern of correlations approximated a cosine curve.[5] The fit of the pattern of correlations to a cosine function is indicated by the variance accounted for (VAF) in the 12 data points by a cosine curve, which, in this particular case, was 99%.[6] Figure 4 shows that those who reported feeling fearful at the moment of the test were also highly likely to report a specific state of Core Affect (activated displeasure) best characterized by the

[4] An unpublished document detailing the Cosine Method is available upon request.

[5] To chart the relation between each external variable and the 12 segments, we rely on the general form of the cosine function: $Y = a + b * \cos(X + d)$, where Y is the correlation between a segment and external variable; X was the angle for the segment. a, b, and d are constants to be estimated. a adjusts the start value of Y; b scales the amplitude of the cosine wave; d adjusts the start value of X when it does not start at 0. If $a = 0$, $b = 1$, and $d = 0$, the general form of the cosine function reduces to the commonly seen $Y = \cos(X)$.

[6] Merely by chance, data can fit a cosine curve with a VAF greater than zero. To quantify this possibility, a Monte Carlo study assigned each angle of the 12-point circumplex to a correlation drawn randomly with replacement from a set of 996 correlations. The 996 correlations were all the correlations observed here between one of the 12-PAC variables and the external correlates (in Studies 3 and 4) at one of three moments. The values for the 12 angles were 0.0°, 34.5°, 62.0°, 90.5°, 125.0°, 152.5°, 179.5°,

Table 7
Testing Circumplexity: Fit Indexes for CIRCUM and RANDALL Analyses

Study	Response format	CIRCUM			RANDALL	
		χ^2	RMSEA	MCSC	CI	*p* value
Study 1	ADJECTIVE	297.50	0.11	−0.71	0.88	0.001
	AGREE	391.59	0.13	−0.82	0.90	0.001
	DESCRIBE	280.37	0.11	−0.83	0.88	0.001
Study 2	ADJECTIVE	158.21	0.12	−0.57	0.91	0.001
	AGREE	132.40	0.11	−0.70	0.92	0.001
	DESCRIBE	123.59	0.10	−0.71	0.85	0.001
Study 3	ADJECTIVE	115.31	0.09	−0.62	0.92	0.001
	AGREE	178.91	0.12	−0.73	0.92	0.001
	DESCRIBE	112.35	0.09	−0.76	0.85	0.001
Study 4 Yesterday	ADJECTIVE	251.25	0.12	−0.65	0.88	0.001
	AGREE	300.42	0.13	−0.78	0.86	0.001
	DESCRIBE	238.54	0.11	−0.79	0.85	0.001
Study 4 Last Saturday	ADJECTIVE	250.46	0.12	−0.66	0.87	0.001
	AGREE	355.76	0.14	−0.75	0.85	0.001
	DESCRIBE	298.44	0.13	−0.78	0.80	0.001

Note. Study 1 ($N = 535$); Study 2 ($N = 190$); Study 3 ($N = 234$); Study 4 ($N = 395$). ADJECTIVE = "Adjective" format; AGREE = "Agree-Disagree" format; DESCRIBE = "Describes Me" format. CIRCUM (Browne, 1992). RANDALL (Tracey, 1997). $df = 40$ for each CIRCUM analysis.

peak of the fitted curve at 149° in the 12-PAC, an angle we term â (a-hat). The magnitude of the relation is estimated as the correlation (in this case estimated as .80) with a vector at exactly 149°, a correlation we term r_{max} (r-max). Fear does not overlap precisely with any one of the 12-PAC variables actually measured. Thus, .80 is interpreted as an estimate of the correlation with a hypothetical variable located at 149° in the 12-PAC space. More generally, the fitted curve in Figure 4 shows the predicted correlation of Fear with every point along the circumplex.

The same procedure was carried out for each external mood variable. Table 8 shows the results for the 20 mood scales included in Study 3 plus 10 scales from Study 1—four from Thayer (1996), four from Larsen and Diener (1992), and two from Watson and Tellegen (1985). For each mood scale, its 12 correlations with the 12-PAC segments fit a cosine curve as demonstrated by the uniformly high VAF ($M = 98.4\%$, $s = 1.5\%$, range = 94% to 100%); all were highly significant. The estimated r_{max} ranged from .20 to .89. If we set aside the measures of implicit affect, the lowest r_{max} value was .41. The two scales of "implicit affect" (Quirin et al., 2009) fell where expected, although with lower magnitude than for other mood scales ($r_{max} = .26$ for Pleasant, and .20 for Unpleasant). The low magnitude supports the validity of distinguishing implicit from explicit Core Affect and suggests the value of developing scales of implicit activation.

Personality variables. The cosine wave technique was used with 38 personality variables. Results are shown in Table 8. VAF varied considerably ($M = 90.1\%$, $s = 17.4\%$, range = 8% to 100%). Remarkably, all but one (DE Cold-Hearted) showed a reliable cosine curve, although two (BC Arrogant-Calculating and Behavioral Activation-Drive in Study 3) showed modest VAF. The explanation of the low VAF values may be seen in the estimated r_{max} values (.10, .09, and .14, respectively) for these three variables. With this small degree of association, the signal to noise ratio is too low to provide clear results. The remaining 35 personality variables all showed significant ($p < .01$) fit to a cosine curve. To illustrate the meaning of these results, consider results for behavioral inhibition scale (Carver & White, 1994). Those individuals who describe their personality as behaviorally inhibited had a moderate tendency to report a specific state of Core Affect (displeasure with slightly elevated arousal), best characterized by the peak of the fitted curve at 175° in the 12-PAC space.

192.0°, 239.0°, 263.0°, 301.0°, and 320.5°; each angle was a mean of observed angles derived from CIRCUM in Studies 3 and 4. For each trial, the column vector was fit by the formula $Y = a + b * \cos(X + d)$, and a VAF was estimated. With 10,000 trials, the distribution of VAF when association between angle and correlation was random was estimated. The mean VAF was 18.1% ($SD = 14.3\%$). Values of VAF equal to or greater than 45.5% were obtained in 5% of cases, values equal to or greater than 57.6% in 1% of cases. These benchmarks are used in Table 8 to determine which VAF values indicate a reliable cosine pattern.

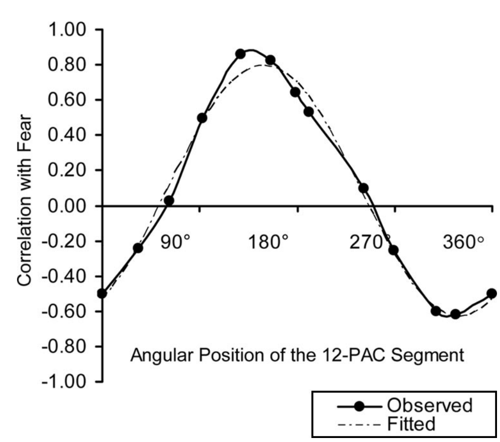


Figure 4. The correlation of Watson and Clark's (1994) mood scale of Fear (ordinate) with each segment of the 12-PAC as a function of the angle within the circumplex for that segment (abscissa). The value for the correlation at 0° is repeated at 360° to show the complete cosine wave (Study 3; $N = 234$).

Table 8
Placing External Variables Within the 12-PAC Structure Via the Cosine Method and the CIRCUM-Extension Procedure

		Cosine method[r]			CIRCUM-extension[s]		
Study	Scale (Cronbach's alpha)	$\hat{a}$	r_{max}	VAF (%)	θ_+	ζ_+	VAF (%)
	MOOD STATE						
3	Pleasure (α = .90)[a]	3°	.88	100**	3°	1.00	99
3	Pleasure Affect Grid (n/a)[b]	8°	.78	99**	8°	.90	99
3	Implicit Pleasant (α = .82)[c]	19°	.26	99**	20°	.26	97
3	Dominance (α = .63)[a]	24°	.51	98**	24°	.60	97
3	Joviality (α = .94)[d]	27°	.89	99**	28°	.97	99
3	Self-assurance (α = .87)[d]	30°	.67	99**	31°	.69	97
1	Activated Pleasant (α = .84)[e]	33°	.81	99**	34°	.85	97
3	Positive Affect (α = .90)[f]	39°	.83	99**	39°	.88	99
1	Positive Affect (α = .87)[f]	40°	.84	99**	41°	.90	98
1	Energy (α = .88)[g]	48°	.81	98**	49°	.88	98
3	Attentiveness (α = .78)[d]	54°	.63	99**	54°	.65	98
3	Arousal Affect Grid (n/a)[b]	63°	.68	98**	62°	.77	97
3	Surprise (α = .80)[d]	71°	.41	97**	71°	.38	83
3	Arousal (α = .90)[a]	86°	.76	99**	86°	.86	99
1	Tension (α = .86)[g]	144°	.83	99**	143°	.88	98
3	Fear (α = .91)[d]	149°	.80	99**	149°	.84	99
1	Activated Unpleasant (α = .85)[e]	154°	.85	99**	154°	.92	99
1	Negative Affect (α = .88)[f]	162°	.87	99**	162°	.95	99
3	Negative Affect (α = .91)[f]	162°	.86	100**	162°	.93	100
3	Hostility (α = .88)[d]	173°	.73	100**	173°	.79	100
3	Implicit Unpleasant (α = .85)[c]	177°	.20	96**	177°	.19	89
3	Guilt (α = .91)[d]	181°	.69	99**	181°	.74	99
3	Sadness (α = .90)[d]	189°	.81	100**	190°	.89	100
3	Shyness (α = .79)[d]	223°	.41	97**	222°	.38	81
3	Fatigue (α = .92)[d]	233°	.72	96**	234°	.82	96
3	Serenity (α = .93)[d]	332°	.81	99**	332°	.87	99
1	Unactivated Unpleasant (α = .89)[e]	218°	.74	95**	220°	.86	95
1	Tiredness (α = .89)[g]	224°	.68	94**	226°	.84	94
1	Calmness (α = .72)[g]	317°	.73	99**	317°	.79	99
1	Unactivated Pleasant (α = .89)[e]	327°	.84	99**	327°	.92	99
	TRAIT						
3	Life Orientation Test (α = .84)[h]	7°	.46	100**	7°	.52	99
4	Trait Pleasure (α = .88)[a]	14°	.43	99**	13°	.53	95
3	Intellect (α = .80)[i]	16°	.08	89**	17°	.10	86
3	Behavioral Activation—Fun seeking (α = .77)[j]	20°	.15	90**	22°	.16	89
4	Behavioral Activation—Fun seeking (α = .81)[j]	23°	.27	97**	28°	.28	91
4	Behavioral Activation—Drive (α = .74)[j]	28°	.24	89**	38°	.22	47
4	Behavioral Activation (α = .81)[j]	29°	.28	95**	37°	.27	71
4	Extraversion (α = .81)[k]	33°	.35	97**	34°	.42	97
4	NO Gregarious-Extraverted (α = .81)[m]	34°	.29	98**	36°	.34	97
4	PA Assured-Dominant (α = .81)[m]	36°	.28	96**	40°	.32	95
4	Dominance (α = .81)[a]	36°	.24	97**	38°	.30	96
4	Extraversion (α = .81)[n]	37°	.30	97**	38°	.36	96
4	Conscientiousness (α = .81)[k]	37°	.21	95**	36°	.27	90
4	Trait Positive Affect (α = .81)[f]	38°	.45	98**	40°	.52	97
3	Behavioral Activation (α = .78)[j]	45°	.18	85**	47°	.17	76
3	Conscientiousness (α = .84)[i]	47°	.10	85**	46°	.13	82
4	Behavioral Activation–Reward (α = .63)[j]	49°	.15	92**	56°	.14	32
3	Behavioral Activation–Drive (α = .73)[j]	55°	.09	53*	59°	.07	00
3	Extraversion (α = .88)[i]	56°	.17	95**	55°	.22	87
4	Trait Arousal (α = .72)[a]	57°	.36	98**	56°	.43	97
3	Behavioral Activation–Reward (α = .68)[j]	72°	.17	91**	73°	.16	84
4	BC Arrogant-Calculating (α = .92)[m]	72°	.14	53*	83°	.10	00
4	Openness to Experience (α = .73)[k]	73°	.14	98**	73°	.17	97
4	LM Warm-Agreeable (α = .89)[m]	132°	.06	89**	132°	.05	80
3	Behavioral Inhibition (α = .78)[j]	175°	.35	99**	176°	.38	99
4	Behavioral Inhibition (α = .79)[j]	175°	.30	97**	173°	.32	93

Table 8 (*continued*)

Study	Scale (Cronbach's alpha)	Cosine method[r]			CIRCUM-extension[s]		
		â	r_{max}	VAF (%)	θ_+	ζ_+	VAF (%)
4	Neuroticism (α = .85)[n]	176°	.46	99**	175°	.49	97
4	Trait Negative Affect (α = .88)[f]	178°	.60	98**	176°	.62	96
3	Trait-Anxiety (α = .92)[p]	179°	.75	100**	179°	.84	99
3	Beck Depression Inventory (α = .87)[q]	182°	.58	100**	183°	.64	100
4	Neuroticism (α = .86)[k]	182°	.48	99**	182°	.53	96
4	FG Aloof-Introverted (α = .88)[m]	203°	.27	97**	204°	.32	96
4	HI Unassured-Submissive (α = .88)[m]	215°	.27	96**	217°	.34	93
4	JK Unassuming-Ingenuous (α = .72)[m]	252°	.03	85**	73°	.00	63
4	DE Cold-hearted (α = .91)[m]	298°	.10	08	195°	.05	00
3	Emotional Stability (α = .80)[i]	339°	.36	99**	339°	.41	98
3	Agreeableness (α = .81)[i]	348°	.16	92**	349°	.17	93
4	Agreeableness (α = .75)[k]	348°	.02	78**	341°	.07	00

Note. Study 1 (N = 535); Study 3 (N = 234); Study 4 (N = 395).
[a] Mehrabian & Russell (1974). [b] Russell, Weiss, & Mendelsohn (1989). [c] Quirin, Kazén, Rohrmann, & Kuhl (2009). [d] Watson & Clark (1994). [e] Larsen & Diener (1992). [f] Watson & Tellegen (1985). [g] Thayer (1996). [h] Scheier & Carver (1992). [i] Saucier (1994). [j] Carver & White (1994). [k] Costa & McCrae (1992). [m] Wiggins (1995). [n] Eysenck & Eysenck (1975). [p] Spielberger (1983). [q] Beck (1967). [r] In the cosine wave technique, a series of 12 correlations between the external variable and each of the 12-PAC segments is fit to a cosine function; see footnote 6. The method produces for each analysis three outcomes: â (a-hat) is the estimated angle of the outside variable within the 12-PAC structure. r_{max}(r-max) is the maximum correlation between the external variable and a vector within the 12-PAC at the angle â. VAF (variance accounted for) is the amount of variance explained by the cosine curve. Significance level of VAF was determined by a Monte Carlo simulation; see footnote 6. [s] In the CIRCUM-extension method, the external variable is located within the structure provided by CIRCUM. The method produces for each analysis three outcomes: θ_+ (thetaplus) is the estimated angle of each outside variable within the 12-PAC structure. ζ_+ (zetaplus) is a communality index, the square root of the proportion of variance of each outside variable explained by the CIRCUM model for the 12-PAC structure. VAF (variance accounted for) is the amount of variance explained when a series of correlations between each outside variable and the 12-PAC segments was fitted to the predetermined CIRCUM function.
* $p < .05$. ** $p < .01$.

The magnitude of the relation is more modest (r_{max} = .35) than it had been for Fear.

Results with personality scales contrast with results from mood scales in understandable ways. Although both analyses showed reliable fit to a cosine, the magnitude of relation differed considerably. This contrast speaks to the debate about the distinction between states and traits (Allen & Potkay, 1981; Zuckerman, 1983). Measures of mood states, such as Fear, showed much higher correlations with the 12-PAC than did measures of personality traits, thus supporting the distinction between states and traits.

Reliability of the cosine technique. The question arises as to which links identified by the cosine wave technique are reliable and meaningful. Reliable VAF was necessary but not sufficient. The key is the value of r_{max} because the greater the magnitude of the relation between the external variable and the 12-PAC structure, the clearer the results should be. One interesting personality trait, Behavioral Inhibition scale, was included in both Study 3 and Study 4; the results were a striking replication despite the difference in methods of the two studies: â was 175° in both. Behavioral Inhibition scale had values of r_{max} of .30 and .35. Behavioral Activation scale was also included in both studies, but showed some discrepancy in â: a difference of 16°. This scale had values of r_{max} of .18 and .28. Studies 3 and 4 also included several other constructs that were measured more than once, although with different scales. Extraversion was assessed three times; the values of â ranged from 33° to 56°. These differences are not huge and may reflect genuine differences in the aspects of Extraversion captured by the different scales, since Extraversion is a multifaceted construct. Gray (1981) viewed Extraversion as based on impulsivity. In contrast, Extraversion assessed by Eysenck and Eysenck's scale has a large component of sociability, with little impulsivity (Wolfe & Kasmer, 1988). Because sociability plays no prominent role in Gray's theory, we would not expect to see a close alignment between Eysenck's Extraversion and Behavioral Activation scale. In our data, Eysenck's Extraversion was placed at 37°, whereas Behavioral Activation scale was at 45° in Study 3 and 29° in Study 4. Neuroticism was assessed twice, with values of r_{max} of .46 and .48; the values of â were close to each other: 176° and 182°. Saucier's Emotional Stability is defined as the flip side of Neuroticism; its â was 339°, which is 180° from 159°. Again, the differences may reflect genuine differences in what are tapped by different trait scales.

Table 8 shows 42 of the 68 values for r_{max} were equal to or greater than .30. In these cases, the VAF was uniformly high (≥94%). Another group of 17 analyses yielded an r_{max} between .15 and .29. In these cases too, the VAF was high (≥85%), although not as high as in the first group. In every case, the placement of the external variable in relation to the 12-PAC and to other external variables was reasonable. One pair of analyses among these 17 concerned Agreeableness, assessed with different scales in different samples, and yet both analyses yielded an estimated â of 348°. Other pairs in this group yielded greater differences, but none were too large. These 17 external variables appear reliably, meaningfully, but weakly related to the 12-PAC.

Finally, 9 analyses yielded an r_{max} less than .15. In these cases, the VAF ranged from 8% to 98%; three of these were not significant at $p < .01$. One of these variables, Saucier's (1994) Intellect is defined as related to Openness to Experience, and yet their estimated values of â differed by 57°. It is difficult to know if the two scales differ this much in their implications for Core Affect or if the signal-to-noise ratio is simply too great. With values of r_{max} this low, the relationship to Core Affect is likely too weak to be of great interest in any case. We therefore suggest setting an r_{max} of .15 or greater as a requirement for concluding that an external variable is related to 12-PAC.

The CIRCUM-Extension Method

A complementary way to place an external variable within the 12-PAC structure is provided by the CIRCUM-extension procedure (M. Browne, personal communication, June 12, 1999), which provides a maximum likelihood estimate of the magnitude of the relation of the external variable to the entire circumplex, and, separately, an estimate of where within the circumplex the external variable falls. ζ_+ (zetaplus) estimates the magnitude of relation; more precisely, it is a communality index, the square root of the proportion of variance of the external variable explained by the CIRCUM model for the 12-PAC structure. θ_+ (thetaplus) estimates the angle within the circumplex for the external variable. Finally, VAF estimates the fit of the circumplex model to that external variable.

Results are given in Table 8. For the 30 mood variables, the mean value of VAF was 96.8% (s = 4.6%, range = 81% – 100%). The mean value of ζ_+ for the 30 mood variables was .77 (s = .21); this high value is consistent with the idea that mood measures are closely related to but not identical with Core Affect. Figure 5 portrays the values of θ_+. Mood variables fell all around the circumference, although they were not equally spaced.

The relation of Core Affect to personality trait measures was similarly mapped. Table 8 gives the results. The mean VAF was 79.0% (s = 31.0%, range = 0% – 100%). Magnitude of relation also varied with a fair range of ζ_+ values (M = .30, s = .19). This range suggests that trait scales vary considerably in their relation to the Core Affect of an arbitrarily chosen moment.

Although the cosine wave technique and the CIRCUM-extension method are based on different statistical assumptions, they yielded extremely similar results. Across the 68 external variables listed in Table 8, r_{max} correlated .99 with ζ_+. Only two large discrepancies occurred (JK Unassuming-Ingenuous and DE Cold-Hearted); in both cases the relationship between the external variable and the 12-PAC was negligible (estimated as .03 and .10 by cosine wave technique; .00 and .05 by CIRCUM-extension, respectively). The signal-to-noise ratio precluded clear results.

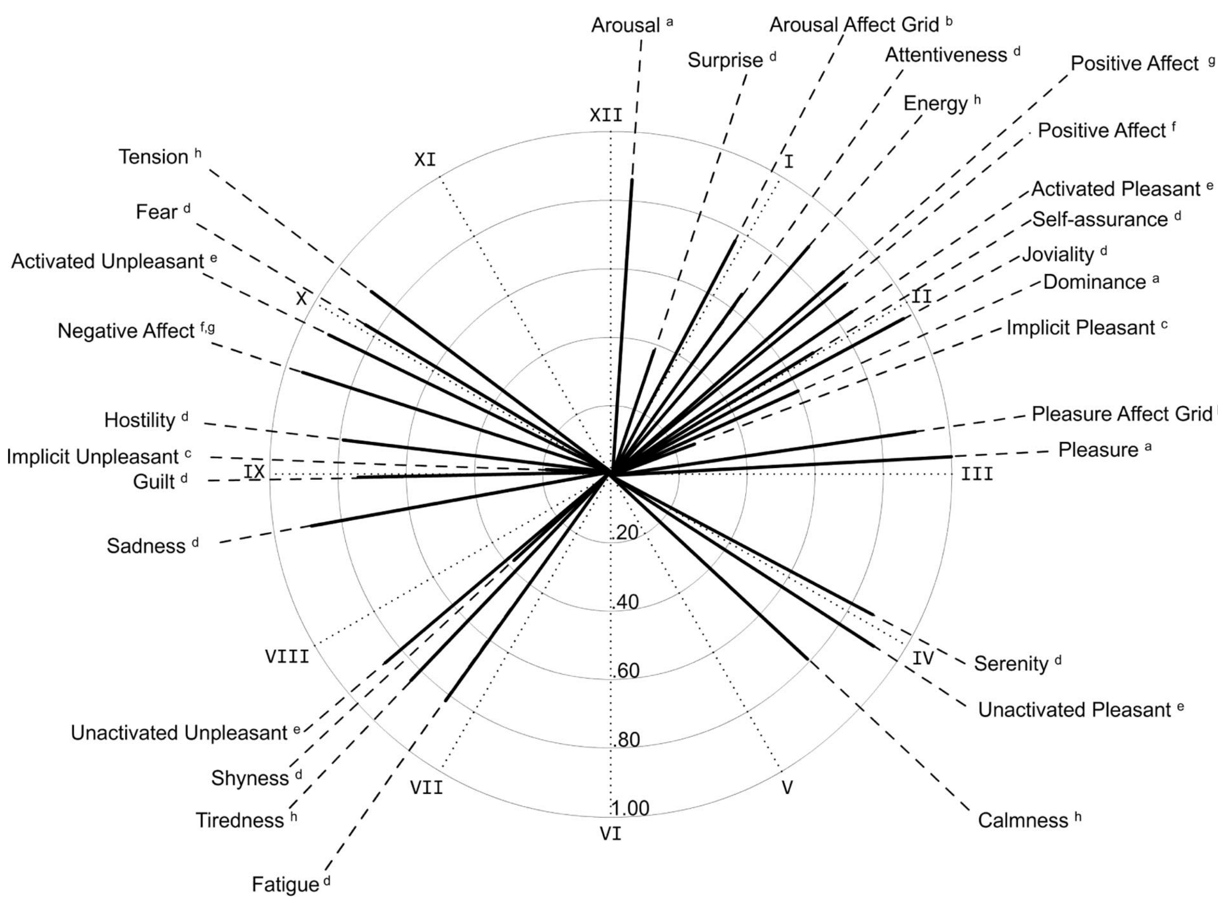


Figure 5. Thirty mood scales treated as external variables and placed within the 12-PAC structure with CIRCUM-extension. Angle shows the θ_+ (thetaplus). The length of the solid line from the center shows ζ_+ (zetaplus). [a] Study 3: Mehrabian and Russell (1974). [b] Study 3: Russell, Weiss, and Mendelsohn (1989). [c] Study 3: Quirin et al. (2009). [d] Study 3: Watson and Clark (1994). [e] Study 1: Larsen and Diener (1992). [f] Study 3: Watson and Tellegen (1985). [g] Study 1: Watson and Tellegen (1985). [h] Study 1: Thayer (1996).

Earlier, we identified 42 of the 68 external variables for which r_{max} was confidently high: .30 or greater. All of these analyses were closely mirrored in the CIRCUM-extension method. We also identified another group of 17 external variables for which r_{max} was between .15 and .29. All of these analyses too were closely mirrored in the CIRCUM-extension results. The greatest discrepancy occurred for Behavioral Activation-Drive, with a 10° difference in the estimated angle on the circumplex. Finally, we identified nine external variables for which r_{max} was less than .15. Remarkably, four of these nine were mirrored in the CIRCUM-extension results. For the remaining five, however, CIRCUM-extension failed to yield a solution (shown by an estimated VAF of 0%) or yielded an estimate of the angle on the circumplex very discrepant from that seen in the cosine wave analysis. Thus, confidence can be placed in the cosine wave or CIRCUM-extension results when the estimated magnitude of the relationship (r_{max} or ζ_+) is .15 or greater. For lower values, no reliable and meaningful relation has been established.

General Discussion and Conclusion

The concept of Core Affect isolates simple feelings that are ever present, although not always salient. Core Affect is not equivalent to "mood" or "emotion," but is a key ingredient in both. The high correlations seen here of Core Affect with common mood scales are consistent with this claim. A simple but instructive descriptive structure of Core Affect is emerging: the 12-PAC schematically portrayed in Figure 1. This structure proved robust across response formats and in our four datasets.

Limitations

Before elaborating on the implications of these results, let us mention some limitations. A descriptive structure, while necessary in any scientific analysis, is but a first step. Our method was correlational, and experimental designs can yield different information about the nature of Core Affect (Larsen, McGraw, & Cacioppo, 2001).

Each method we used can be questioned. We twice used a "current moment" method, once outside the lab and once inside. Perhaps the feelings that exist in the lab are milder than those that exist outside. Outside, perhaps some participants failed to carry out our instructions to complete the questionnaire at a certain time. Whether inside or outside the lab, participants were seated about to start a questionnaire. Feelings at such a moment may be restricted in range.

In order to get a broader range of moments, we twice used a "remembered moments" method. As expected, this method yielded greater variance in the 12 Core Affect segments: for the ADJECTIVE format, "remembered moments" gave a mean standard deviation of .95, "current moments" .90. The comparable figures for the AGREE format were 1.00 and .93; those for the DESCRIBE format were .86 and .81. Still, reliance on memory might have been a problem. The reconstructive nature of memory suggests that some orderliness might be introduced after the fact. (Indeed, all four studies relied on a lengthy questionnaire, introduced for psychometric reasons. With a lengthy questionnaire, even the "current moment" might be described from memory.)

What is reassuring is that a very similar structure and patterns of external correlates emerged across these variations in method. Memory is less of an issue for the current moment, restricted variance less an issue for remembered moments. Research with more methodological variation is needed to verify the robustness of our conclusions, but the studies reported here, especially against the background of prior research on mood and emotion, makes the 12-PAC a promising hypothesis and tool.

So far, we have proceeded as if the structure of Core Affect is static across contexts and cultures. Some writers suggested that, rather than static, the structure is dynamic, that is, influenced by the context of assessment or by the cultural background of the participants. For example, Zautra, Berkhof, and Nicolson (2002; see also Perunovic, Heller, & Rafaeli, 2007) showed that the observed correlation between Positive Affect and Negative Affect changed with context. The correlation between the two scales averaged –.53 in context A (in which the participant also reported a recent stressful event), but –.33 in context B (in which the participant reported no such event). Bagozzi, Wong, and Yi (1999) reported that the correlation was weaker when the participants were Asian than when North American (see also Yik, 2007, 2009a).

Such evidence is no more than suggestive. A difference in the zero-order correlation between two measured variables has various interpretations and is not the most revealing statistic for questions about the static versus dynamic nature of Core Affect space. Our cosine wave and CIRCUM-extension procedures would provide a more revealing analysis. The key question is whether an observed difference in the correlation between two variables corresponds to a genuine difference in structure, which would correspond to a difference in the angle between them within the 12-PAC structure. An alternative possibility is that the observed difference in the correlation corresponds simply to a difference in the magnitude of the relation between the two variables but without a structural difference within the 12-PAC. To test this idea, the two scales used by Zautra and his colleagues could be treated as external variables and then placed within our 12-PAC structure twice, once for each context. Significant difference in $\hat{a}$ (or θ_+) between the two contexts, resulting in the angle between Positive Affect and Negative Affect being different, would show a genuine structural difference. On the other hand, differences in observed correlation between two contexts for the two scales could reflect merely a difference in r_{max} (or ζ_+). In this case, the difference in the observed correlation may simply reflect differences in the variances of the two scales. (e.g., in Zautra et al.'s 2002 study, both scales showed greater variance in context A than in context B).

Circumplex Structure

The circumplex provides a surprisingly good approximation to the correlational structure among items relevant to Core Affect. Mood and emotion often fit a circumplex quite well (Fabrigar et al., 1997; Remington et al., 2000). The fit of a circumplex raises several issues.

Indices of fit. We conclude that our hypothesized structure fit the data well. By conventional standards, however, the fit indexes were mixed. The CI and *p* value indexes from RANDALL were uniformly supportive. So were APGI and CFI. However, the χ^2 was often significant, as was expected because of large sample size. The RMSEA values were what have commonly been thought of as marginal: .10 to .14. As indicated earlier, when variables are very highly correlated, RMSEA can become large even when the model reproduces the correlation matrix well.

Another reason for the high values of RMSEA obtained with CIRCUM is that CIRCUM does not take into account systematic errors introduced by the specific method of measurement (Green, Goldman, & Salovey, 1993). Another is that substantive dimensions other than valence and activation account for some of the variance in our 12-PAC scales (see Mauro, Sato, & Tucker, 1992).

Rotation. Much has been written debating valence-arousal models, such as that assumed here, versus such models as those proposed by Watson and Tellegen (1985) or Thayer (1989). The choice has sometimes been phrased as between two rotations. Even integration of the two structures does not automatically select the best rotation. Factor analysis, whether exploratory or confirmatory, does not determine rotation, because any set of nonredundant factors would define the space equally well from a mathematical point of view. In that sense, the rotation seen here with Pleasure at 0° is arbitrary. Rigid rotation would leave the structure intact and no conclusions follow from the chosen rotation. The present study shows that the number of possible rotations is not limited to two. Indeed, items could be selected to define meaningful scales at almost any angle within the space, and therefore many rotations are feasible.

These considerations leave us with no psychometric solution to the question of rotation. But perhaps this is not a bad place to be left. Rotation is ultimately a question of the interpretation of the space. Interpretation is a conceptual issue, involving a network of assumptions and empirical results that extend far beyond correlational analyses. Therefore, we agree with Reisenzein (1994) and Larsen and Diener (1992) that the question of rotation is best viewed as a theoretical issue and that the valence and activation dimensions provide simple and heuristic concepts whose value extends far beyond the interpretation of a factor structure.

Simple structure. Watson and Tellegen's (1985) model has been said to show simple structure and for that reason to be preferable to a circumplex (e.g., Morris, 1989; Tellegen, 1985; Watson & Tellegen, 1985; Zevon & Tellegen, 1982). Traditionally, simple structure occurs when each observed variable correlates principally with only one of the factors. When the factors are orthogonal, variables fall into tight clusters 90° apart. Core Affect does not show simple structure in this traditional sense (Russell & Barrett, 1999). (Nor did Watson & Tellegen's 1985 theoretical model, shown in their Figure 1, predict simple structure in this sense.)

Like the question of rotation, the important issue here is a conceptual one. Is there some theoretical reason that Core Affect items should fall in clusters 45° or 90° apart? We can find no plausible theory that would make this prediction. In contrast, there is a plausible account of why items saturated in Core Affect might fall at any point around a circle. If valence and arousal are independent psychological processes, then any combination of values could occur. Different items simply specify different proportions of valence and arousal. Each cluster of items represented as a vector can therefore fall at any angle in our two-dimensional space. Because each vector has the same maximum length (representing 100% of its variance), the ends of vectors saturated in Core Affect form a circle rather than, for example, a square or triangle.

Integration

Our 12-PAC structure provides a perspective from which circumplexes, dimensions, and categories can be integrated. First, although the 12-PAC is a *circumplex*, it incorporates *dimensions*. Its horizontal axis captures the traditional idea that such feelings involve a positive (feels good) versus negative (feels bad) valence dimension. From the time of Socrates, writers have described the role of pleasure and displeasure in human affairs. Pleasure is once again playing a significant theoretical role in psychology (Cabanac, 1995; Kahneman, Diener, & Schwarz, 1999; Russell, 2003b; Shizgal & Conover, 1996). On the other hand, the horizontal axis of Core Affect is not intended to represent everything that can be labeled "positive versus negative." We do not equate pleasure-displeasure with adaptive versus maladaptive, morally good versus bad, or socially appropriate versus inappropriate behavior, because these distinctions point to important differences. For example, displeasure can be adaptive (consider the function of pain), morally appropriate (consider the function of feeling remorse), or socially appropriate (consider the function of embarrassment).

The vertical axis captures the long standing research finding that a major dimension of mood and emotion involves arousal. The arousal dimension has been, and remains, prominent in psychological theories of mood and emotion (Berlyne, 1960; Cacioppo, Berntson, Larsen, Poehlmann, & Ito, 2000; Cannon, 1927; Duffy, 1957; Hebb, 1955; Heller, 1990; Lang, 1994; Lindsley, 1951; Mandler, 1951; Schachter & Singer, 1962; Thayer, 1996; Zillmann, 1983). On our account, arousal refers to how energetic one feels, independent of whether that feeling is positive or negative. One can feel activated in a positive (excited) or negative (agitated) way. One can feel deactivated in a positive (placid) or negative (sluggish) way.

The 12-PAC also incorporates *categories*. Our claim is that Core Affect is a key ingredient in—but not the whole of—each category of mood and emotion. Our hypothesis is illustrated in Figure 5 where commonly used scales for categories of mood are placed in the 12-PAC structure. Watson and Tellegen's (1985) scales showed an interesting range of ζ_+ values: The highest was .89 for the category of Sadness, the lowest .36 for Surprise. These figures reflect different proportions of variance in the mood scale accounted for by Core Affect. So, when a participant reports Sadness, that participant is mainly reporting a state of Core Affect. With Surprise, in contrast, the main ingredient is not Core Affect; indeed, surprise is often included among the emotions, meaning that it includes not just Core Affect, but an antecedent event, appraisal of that event, and physiological and behavioral reactions. For Surprise, the main ingredient is the occurrence of an unexpected event, which increases one's level of felt activation. (If the unexpected event is also pleasant, Core Affect moves to the right, if unpleasant to the left, of Figure 1. Surprise can be either. On average, our participants appear to have had more pleasant than unpleasant surprises—hence the angle of 71° rather than 90°.) The principal reason that the ζ_+ for surprise is low may be that surprising events are not the only or even the main source of activation in the sample of moments gathered here. In all, these results support our hypothesis that mood scales contain a very large component of Core Affect. Although we did not explore emotion categories here directly, the results encourage mapping of the domain of emotion from the perspective just outlined.

Relation of 12-PAC to Other Variables

Dividing the space into 12 segments, roughly 30° apart, promises to provide a finer measurement for Core Affect than previously available. In the cosine wave and the CIRCUM-extension procedures, the entire structure of Core Affect is used to assess the relation of Core Affect to another (external) variable. Using an entire structure rather than individual variables to represent Core Affect opens the door to a new approach to assessment. For example, a perennial problem in assessment is item selection. This problem occurs in the construction of standardized scales and occurs in spades for ad hoc scales. The cosine wave and the CIRCUM-extension techniques mitigate this problem. One bootstraps from the items to the full structure, rendering selection of items less critical (see Saucier, 1997). Our hypothesis to be tested empirically is that, for a given external variable, similar values of ζ_+ and θ_+ can be obtained in diverse item pools of Core Affect, provided only that they give an adequate assessment of the entire structure and a good estimate of one point, such as the scale to be fixed at 0°.

For a more substantive example, consider Heponiemi, Keltikangas-Jarvinen, Puttonen, and Ravaja (2005), who examined risk factors influencing health outcomes including heart disease. After each of a series of tasks, current mood was assessed. Although the researchers drew on a circumplex model, they treated each octant of the circumplex as a separate variable. The result was a list of eight outcomes. Our proposed techniques offer the potential of a more parsimonious and sensitive measure because the resulting measure would represent Core Affect by a single location on the circumplex, to which all 12 Core Affect segments contribute. The effect on task performance could be pinpointed to a single locus for the entire Core Affect space, perhaps revealing subtle differences between groups that would not be apparent from the list of eight separate outcomes. Equally important, our technique offers a simple integrated way of conceptualizing the results.

Table 8 shows that our techniques produce highly replicable results even when the overlap in variance between 12-PAC and the external variable is small. An estimated degree of overlap (r_{max} or ζ_+) of .15 appeared sufficient to obtain reliable and meaningful results. A correlation of .15 is equivalent to an overlap of 2.25% of variance. The CIRCUM-extension procedure is the mathematically more sophisticated approach. Still, our cosine technique provided a close approximation to it, and has the advantage that it can be used even when CIRCUM cannot.

Measures of Core Affect

The 36 12-PAC scales are measures of Core Affect. They are not direct measures of "mood" or "emotion," but they are relevant. If mood involves principally prolonged Core Affect; then assessment of mood would involve both Core Affect and time. If an emotion typically involves not just a feeling of Core Affect but its attribution to an object, appraisals of that object, and behaviors directed at the object, then proper assessment of emotion would involve such factors. Assessment of Core Affect is necessary but not sufficient in the assessment of mood and emotion.

Participants take about 25 min to complete all 36 12-PAC scales. Such lengthy assessment is necessary only in certain contexts. Basic research on structural relations (such as that reported here) requires that measurement error be maximally controlled and therefore benefits from the use of all 36 scales. Green et al. (1999) detailed the advantages of using different response formats to assess the same variable. For many research contexts, however, time and effort can be saved by using a subset of the 36. The convergence across three response formats seen here indicates that one format will suffice in use of the cosine or Circum-extension technique. Using one format cuts time by two thirds.

If the advantages of three different formats are to be retained, one could save time and effort by limiting each format to just four scales: Pleasant, Unpleasant, Activated, and Deactivated. In this case, the Unpleasant and Deactivated scales can be treated as negatively keyed versions of the Pleasant and Activated scales respectively. Thus difference scores yield estimates of a person's location on the major axes. From these, scores on all remaining scales can be estimated if needed. Many research contexts allow an even simpler procedure: use one response format and the same four cornerstone scales, again with reverse scoring where needed. With the ADJECTIVE format, this questionnaire can be completed in less than 5 min.

Even simpler methods are available. When participants provide ratings of valence and arousal, their scores fall somewhere on a square grid. Russell et al. (1989) developed a one-item scale of just such a grid. A single-item scale is likely less psychometrically sound than multi-item inventories, but the psychometrics of the Affect Grid were reasonably sound. Its main use is for repeated, or even continuous, measurement of Core Affect.

Future Directions

The geometric model of Figure 1 is a valuable and heuristic tool. Still, it remains only an approximation. Psychology is not geometry. The 169 items cannot be completely accounted for by two dimensions. Conceptually, we hypothesize that Core Affect is part of, but not the whole of, mood and emotion. The 12 variables of Figure 1 are not exactly 30° apart, and there is no reason that they should be. The discrepancies found for the new scales from the hypothesized 30° were as great as the discrepancies found with earlier scales from the hypothesized 45°.

Psychology is not geometry but it is science. Greater precision in description and assessment promotes the clarification of hypotheses and concepts. A heuristic notion can be forged into a hypothesis precise enough to be tested and then modified based on the results of that testing. The research reported here was a preliminary and small part of a larger project exploring the notion of Core Affect. In this step we are moving from a theorized construct to something measurable and describable in detail. With these tools, hypotheses about Core Affect and its role in various psychological processes can be examined with greater precision than available before.

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Appendix

12-Point Affect Circumplex (12-PAC) Scales

Measures of the 12-PAC consist of three separate questionnaires, each in a different format. Hence, there are 36 scales in all. Here we give the "Remembered Moments" instruction for each format and its items. These instructions would be followed by all items for that format in a random order. An individual's score on each scale is calculated as the mean of that individual's responses to the items of that scale; thus, the potential range corresponds to the range of the response format. Psychometric properties of the 36 scales in Studies 1, 2, 3, and 4 are given in Table A2.

Instructions for Three Response Formats

The Adjective Format

This scale consists of a number of words that describe feelings, mood, and emotions. Please indicate to what extent you felt each of these at the REMEMBERED MOMENT.

Use the following scale to record your answers.

1	2	3	4	5
Not at all	A little	Moderately	Quite a bit	Extremely

The "Agree-Disagree" Format

This questionnaire contains 61 statements about how you felt at the REMEMBERED MOMENT. Please indicate how much you agree or disagree with each statement.

Please use the following scale to record your answer.

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

The "Describes Me" Format

Please use the following response options to indicate how well each phrase describes your feeling at the REMEMBERED MOMENT.

1	2	3	4
Not at all	Not very well	Somewhat	Very well

(*Appendix continues*)

Table A1
Item Content of the 12-PAC Scales

Hypothetical angle	Segment	Response format		
		ADJECTIVE	AGREE	DESCRIBE
0°	III. Pleasure	Happy Content Satisfied Pleased	I was satisfied. I was happy I felt content.	My mood was positive. Overall, I was satisfied. Everything felt comfortable.*
30°	II. Activated Pleasure	Proud Enthusiastic Euphoric	Right then, life felt terrific. I felt pretty enthusiastic about my life right then. I was feeling energetic and positive. I was feeling lively and cheerful. I was enthused about what I was doing. I was feeling inspired. I was feeling elated.	I felt elated. I felt very inspired. I felt enthusiastic.
60°	I. Pleasant Activation	Energetic Full of pep Excited Wakeful Attentive Wide awake Active Alert Vigorous	I was full of pep and energy. I felt energetic and vigorous. My mind was quick and alert.	I felt active and peppy. I felt alive and active. I felt very lively. Right then, I was sharp and attentive. I felt full of energy. Right then, I was brimming with vigor.
90°	XII. Activation	Aroused Hyperactivated Intense	My body felt activated. I was in a state of frenzied excitement. I was filled with energy and tension. I was feeling stirred up.	I was keyed up. I was full of energy and tension. I was stirred up. My mind was racing.
120°	XI. Unpleasant Activation	Anxious Frenzied Jittery Nervous	For some reason, I was feeling stirred up and jittery. I was feeling “jittery.” For some reason, I had been feeling sort of nervous. I felt frenzied.	I felt jittery for some reason. I was anxious. My body was trembling with tension. At that moment, I felt nervous. My tension was quite intense. My mind was frantically agitated. I felt a lot of tension.
150°	X. Activated Displeasure	Scared Upset Shaky Fearful Clutched up	I felt tense. I was annoyed by something. I felt “clutched up”. I was feeling pretty fearful at that moment. I felt on edge.	I felt guilty about something that I had said or done. For some reason, I felt scared and afraid. I felt ashamed of myself. I felt angry. I felt distressed.

(*Appendix continues*)

Table A1 (*continued*)

Hypothetical angle	Segment	Response format: ADJECTIVE	AGREE	DESCRIBE
		Tense Ashamed Guilty Agitated Hostile	I felt worried. I felt agitated. Right then, life felt like one big stress. Right then, life felt like one big struggle. I was bothered by something. I was feeling pretty angry at that moment.	I felt irritated at something. I felt disturbed and upset.
180°	IX. Displeasure	Troubled Miserable Unhappy Dissatisfied	I was dissatisfied. I was unhappy. I was miserable. I was in agony.*	I was feeling troubled. My mood was NOT good. I felt unhappy. My mood was negative.*
210°	VIII.Deactivated Displeasure	Sad Down Gloomy Blue Melancholy	I felt sad and blue. I was sadly slow. Everything seemed depressing.*	I was surrounded with gloom and doom. My mood was melancholy and down. I was weighed down with depression.*
240°	VII. UnpleasantDeactivation	Droopy Drowsy Dull Bored Sluggish Tired	Everything seemed boring. I felt tired. My body was sluggish. Things seemed pretty dull right then. I felt droopy and drowsy. I was having trouble staying awake.	I was so tired. I felt drowsy. Things were dull and boring. I felt sluggish and slow.
270°	VI. Deactivation	Quiet Still	I was feeling quiet. My body felt still. I felt placid, near sleep.*	I was feeling placid, low in energy. My mind and body were resting, near sleep. My body was in a quiet, still state. My internal engine was running slowly and smoothly.
300°	V. Pleasant Deactivation	Placid Relaxed Tranquil At rest Calm	I was feeling placid. All of me felt at rest. My pace was leisurely and quiescent. I was floating in a sea of tranquility. I was too calm to worry about anything.	My body was at rest. I was relaxed. My body was tranquil. Right then, I was calm about things.
330°	IV. Deactivated Pleasure	Serene Soothed Peaceful At ease Secure	I was blissfully at ease. I was feeling calm and rested. I was serenely at peace.* My body felt soothed and comforted.*	My mind was soothed and unperturbed. My mind was pleasantly at ease. My mind was at peace with the world.*

* Items added in Studies 2 to 4.

(*Appendix continues*)

Table A2

Segment (Hypothetical angle)	# items	Study 1				Study 2				Study 3				Study 4 Yesterday				Study 4 Last Saturday			
		Angle	Mean	*SD*	α	Angle	Mean	*SD*	α	Angle	Mean	*SD*	α	Angle	Mean	*SD*	α	Angle	Mean	*SD*	α
III. Pleasure (0°)																					
ADJECTIVE	4	0°	2.66	1.04	.91	0°	2.88	1.02	.91	0°	2.72	1.01	.92	0°	2.89	1.03	.91	0°	3.00	1.06	.92
AGREE	3	355°	3.12	1.05	.91	6°	3.37	.95	.85	4°	3.25	1.01	.90	1°	3.18	1.08	.91	5°	3.27	1.08	.91
DESCRIBE	3	358°	2.68	.93	.86	0°	2.71	.88	.86	2°	2.61	.89	.87	359°	2.67	.96	.89	359°	2.71	.96	.90
II. Activated Pleasure (30°)																					
ADJECTIVE	3	29°	2.10	.89	.71	47°	2.25	.87	.76	40°	2.20	.89	.76	38°	2.45	.96	.75	39°	2.57	1.01	.79
AGREE	7	26°	2.60	.90	.92	43°	2.79	.82	.89	36°	2.64	.79	.88	35°	2.68	.95	.92	38°	2.77	.94	.91
DESCRIBE	3	32°	2.08	.79	.81	45°	2.13	.82	.83	45°	2.04	.78	.82	41°	2.20	.88	.85	43°	2.28	.88	.86
I. Pleasant Activation (60°)																					
ADJECTIVE	9	61°	2.44	.82	.90	78°	2.24	.82	.92	74°	2.27	.82	.92	70°	2.58	.99	.94	72°	2.77	.96	.93
AGREE	3	56°	2.57	.95	.83	73°	2.68	.92	.82	69°	2.66	.92	.83	66°	2.70	1.05	.88	65°	2.81	1.04	.86
DESCRIBE	6	53°	2.13	.83	.93	72°	1.99	.78	.92	70°	1.97	.80	.93	64°	2.14	.91	.94	65°	2.27	.88	.93
XII. Activation (90°)																					
ADJECTIVE	3	87°	2.10	.85	.65	99°	2.01	.79	.64	99°	2.12	.91	.78	87°	2.32	.99	.73	94°	2.51	.95	.71
AGREE	4	93°	2.57	.87	.77	105°	2.35	.83	.78	100°	2.43	.89	.80	94°	2.48	.90	.79	99°	2.61	.88	.77
DESCRIBE	4	98°	2.31	.76	.77	113°	1.88	.72	.82	103°	1.96	.82	.86	98°	2.11	.83	.85	102°	2.26	.80	.81
XI. Unpleasant Activation (120°)																					
ADJECTIVE	4	122°	2.17	1.00	.85	132°	1.94	.88	.82	129°	2.16	1.04	.88	122°	2.22	.98	.82	124°	2.36	.99	.82
AGREE	4	121°	2.53	1.07	.86	130°	2.14	.96	.85	128°	2.31	1.04	.86	125°	2.29	1.01	.86	128°	2.37	1.03	.86
DESCRIBE	7	128°	2.08	.86	.92	139°	1.70	.71	.90	138°	1.84	.81	.92	131°	1.86	.81	.92	137°	1.91	.80	.92
X. Activated Displeasure (150°)																					
ADJECTIVE	10	147°	1.83	.79	.90	160°	1.69	.78	.92	153°	1.73	.79	.92	146°	1.85	.85	.91	151°	1.87	.88	.92
AGREE	11	150°	2.60	1.04	.94	160°	2.32	.98	.94	157°	2.45	.96	.94	151°	2.39	1.06	.95	154°	2.37	1.07	.95
DESCRIBE	7	156°	1.90	.79	.88	176°	1.61	.74	.92	164°	1.71	.73	.90	157°	1.76	.79	.90	164°	1.77	.83	.92
IX. Displeasure (180°)																					
ADJECTIVE	4	174°	2.04	1.04	.89	185°	1.87	.93	.88	176°	1.88	.93	.88	175°	2.09	1.03	.89	174°	2.04	1.10	.91
AGREE	4	180°	2.30	1.16	.89	188°	1.91	.88	.87	182°	2.00	.90	.88	184°	2.07	1.07	.89	182°	2.02	1.11	.91
DESCRIBE	4	173°	2.17	.98	.90	186°	1.82	.93	.92	180°	1.92	.93	.92	178°	2.07	1.02	.93	177°	1.94	1.04	.95
VIII. Deactivated Displeasure (210°)																					
ADJECTIVE	5	187°	1.83	.88	.89	196°	1.75	.89	.93	193°	1.80	.89	.93	186°	1.94	1.00	.93	185°	1.90	1.04	.93
AGREE	3	201°	2.18	.99	.71	206°	1.95	.97	.87	195°	2.03	.99	.86	199°	2.09	1.12	.89	198°	1.98	1.11	.89
DESCRIBE	3	190°	1.85	.89	.83	202°	1.55	.76	.86	192°	1.63	.80	.89	192°	1.81	.93	.92	189°	1.72	.96	.92
VII. Unpleasant Deactivation (240°)																					
ADJECTIVE	6	234°	2.17	.95	.89	247°	2.34	.93	.88	247°	2.28	.93	.90	241°	2.31	1.00	.88	239°	2.18	.95	.88
AGREE	6	238°	2.73	1.01	.90	250°	2.62	.96	.87	250°	2.65	.95	.87	243°	2.55	1.13	.92	246°	2.33	1.05	.92
DESCRIBE	4	241°	2.27	.91	.89	252°	2.13	.88	.87	253°	2.19	.86	.86	243°	2.16	.96	.90	246°	1.97	.90	.89
VI. Deactivation (270°)																					
ADJECTIVE	2	275°	2.56	1.10	.67	282°	2.69	.98	.70	281°	2.49	.92	.70	265°	2.40	1.02	.73	265°	2.34	1.04	.77
AGREE	3	272°	2.82	.98	.64	273°	2.96	.97	.75	272°	2.87	.93	.75	262°	2.57	1.04	.80	269°	2.42	.98	.79
DESCRIBE	4	274°	2.21	.68	.68	282°	2.31	.72	.75	287°	2.24	.74	.79	273°	2.17	.74	.76	276°	2.06	.70	.73
V. Pleasant Deactivation (300°)																					
ADJECTIVE	5	305°	2.47	.87	.84	310°	2.71	.90	.86	314°	2.52	.89	.87	297°	2.52	.81	.81	300°	2.49	.78	.78
AGREE	5	305°	2.46	.81	.80	303°	2.70	.81	.80	304°	2.57	.87	.83	294°	2.44	.80	.79	298°	2.39	.80	.79
DESCRIBE	4	304°	2.33	.84	.88	317°	2.54	.79	.86	322°	2.34	.84	.89	310°	2.30	.75	.85	311°	2.29	.75	.85
IV. Deactivated Pleasure (330°)																					
ADJECTIVE	5	323°	2.53	.92	.86	322°	2.71	.93	.87	326°	2.51	.95	.90	315°	2.57	.84	.83	318°	2.59	.86	.84
AGREE	4	317°	2.51	1.02	.81	326°	2.75	.95	.87	329°	2.57	.95	.89	316°	2.49	.91	.87	317°	2.54	.96	.88
DESCRIBE	3	321°	2.23	.92	.86	330°	2.41	.85	.87	334°	2.22	.89	.90	324°	2.23	.83	.87	323°	2.27	.87	.89

Note. Study 1 (N = 535); Study 2 (N = 190); Study 3 (N = 234); Study 4 (N = 395). # items = No. of items used to define each scale in Studies 2 to 4. Five AGREE and four DESCRIBE items were added in Studies 2 to 4. Possible scores range from 1 to 5 for the ADJECTIVE and AGREE formats; 1 to 4 for DESCRIBE format. Angle was computed in a CIRCUM of 36 scales. The fit indexes for the CIRCUM analysis of the 36 scales are as follows. Study 1: $\chi^2(556, N = 535) = 3324.34$, RMSEA = .10, and MCSC = –.82; Study 2: $\chi^2(556, N = 190) = 1988.85$, RMSEA = .12, and MCSC = –.74; Study 3: $\chi^2(556, N = 234) = 12.34$, RMSEA = .13, and MCSC = –.81; for Study 4 Yesterday: $\chi^2(556, N = 395) = 3124.81$, RMSEA = .11, and MCSC = –.81; and for Study 4 Last Saturday: $\chi^2(556, N = 395) = 3370.67$, RMSEA = .11, and MCSC = –.78.

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